CARBON PRODUCTS
FROM PEAT

30 April 1985

Montreal Engineering Company Limited
First Rexdale Place
155 Rexdale Blvd.
Rexdale, Ontario
M9W 5Z8

TABLE OF CONTENTS

		PAGE
EXECUTIVE SUMMARY		xi
RÉSUMÉ À L'INTENTION DE LA DIRECTION		xix
PART I.	INTRODUCTION	1
	1.1 INTRODUCTION	3
	1.2 TERMS OF REFERENCE	3
	1.3 APPROACH AND PRESENTATION	4
PART 2.	PRODUCTION AND CONSUMPTION OF COKE	7
	2.1 GLOBAL PRODUCTION STATISTICS	9
	2.2 GLOBAL PRODUCTION STATISTICS	9
	221 COAL COKE	9
	222 PETROLEUM COKE	13
	223 FEEDSTOCKS FOR COKE	14
	.1 Coal Coke	14
	.2 Petroleum Coke	15
	2.3 USES OF COKE	15
	231 STEEL INDUSTRY	15
	.1 Blast Furnaces	18
	.2 Steel Production Furnaces	19
	.3 Direct Reduction Furnaces	20
	.4 Cupola Furnaces	22
	.5 Iron Sinter and Iron Pellets	23
	232 PETROLEUM COKE USES	23
	233 OTHER USES	25
	.1 Reduction Processes	25
	.2 Other Processes Using Coke	26
	2.4 SUMMARY	26
PART 3.	PRODUCTION AND CONSUMPTION OF ACTIVATED CARBON	29
	3.1 INTRODUCTION	31
	3.2 GLOBAL PRODUCTION	31
	321 FEEDSTOCK FOR ACTIVATED CARBONS	33
	3.3 PRODUCTION OF PEAT ACTIVATED CARBONS	34
	3.4 USES OF ACTIVATED CARBONS	38
	341 WATER-PHASE ADSORBENTS	38
	342 GAS-PHASE ADSORBENTS	40
	343 CATALYTIC GRADE ACTIVE CARBONS	41
	3.5 SUMMARY	42

TABLE OF CONTENTS (Cont'd)

		PAGE
PART 4.	PRODUCTION AND CONSUMPTION OF CARBON BLACK	43
	4.1 INTRODUCTION	45
	4.2 GLOBAL PRODUCTION STATISTICS	45
	421 CARBON BLACK DEMAND	47
	422 FEEDSTOCKS	49
	4.3 SUMMARY	50
PART 5.	PRODUCTION AND CONSUMPTION OF WAXES	51
	5.1 INTRODUCTION	53
	5.2 PEAT WAXES	53
	521 MONTAN AND CARNAUBA WAXES	54
	522 SYNTHETIC WAXES	55
	523 PARAFFIN WAXES	55
	5.3 SUMMARY	56
PART 6.	PRODUCTION AND CONSUMPTION OF TARS	57
	6.1 INTRODUCTION	59
	6.2 GLOBAL PRODUCTION STATISTICS	59
	6.3 USES OF TAR	60
	631 COAL TARS	60
	632 PEAT TARS	60
	6.4 SUMMARY	62
PART 7.	PEAT COKE PREPARATION AND CHARACTERISTICS	63
	7.1 INTRODUCTION	65
	7.2 PEAT COKE PREPARATION	65
	721 QUALITY OF PEAT	66
	722 TREATMENT OF RAW PEAT	66
	723 COKING OF PEAT	71
	7.3 PEAT COKE CHARACTERISTICS	74
	7.4 PEAT COKE APPLICATIONS	79
	741 BLAST FURNACE COKE	79
	742 ELECTRIC FURNACES	80
	743 DIRECT REDUCTION FURNACE COKE AND IRON ORE UPGRADING	82
	744 FOUNDRY COKES	82
	7.5 SUMMARY	84

TABLE OF CONTENTS (Cont'd)

		PAGE
PART 8.	PRODUCTION PROCESSES FOR MANUFACTURING PEAT COKE	85
	8.1 INTRODUCTION	87
	8.2 CURRENT PRODUCTION PROCESSES	87
	821 THE OUTOKUMPU OY PEAT COKE FACTORY	87
	822 PEAT COKE FACTORY AT ELISABETHFEHN	90
	823 PEAT COKING PROCESSES UNDER DEVELOPMENT	93
	.1 Lurgi-Salem Hearth Oven	93
	.2 Lurgi-Spuhlgas Process	95
	8.3 SUMMARY	98
PART 9.	PEAT COKE PRODUCTION COSTS	99
	9.1 INTRODUCTION	101
	911 ASSUMPTIONS AND METHODOLOGY	101
	9.2 MINING	102
	9.3 PEAT COKE PRODUCTION	102
	931 OUTOKUMPU OY PROCESS	102
	932 WIELANDT PROCESS	105
	933 LURGI-SALEM PROCESS	105
	9.4 COKE PRICES	106
	9.5 SUMMARY	108
PART 10.	CURRENT PRODUCERS AND CONSUMERS OF CARBON PRODUCTS IN CANADA	111
	10.1 INTRODUCTION	113
	10.2 COKE	113
	1021 PRODUCTION OF COAL COKES	113
	1022 FEEDSTOCKS	115
	1023 PETROLEUM COKE PRODUCTION	115
	.1 Imports and Exports of Coal Coke	116
	.2 Imports and Exports of Petroleum Coke	117
	1024 CONSUMPTION OF COKE IN CANADA	117
	.1 Geographical Breakdown	120
	10.3 ACTIVATED CARBON	125
	1031 ACTIVATED CARBON PRODUCTION	125
	1032 ACTIVATED CARBON IMPORTS	125
	1033 CONSUMPTION OF ACTIVATED CARBON	128
	10.4 TARS	129
	1041 TAR PRODUCTION	129
	1042 TAR CONSUMPTION	129

TABLE OF CONTENTS (Cont'd)

		PAGE
10.5	WAXES	130
	1051 WAX PRODUCTION	130
	1052 IMPORTS	131
	1053 WAX CONSUMPTION	132
10.6	CARBON BLACK	132
	1061 CARBON BLACK PRODUCTION	132
	1062 CARBON BLACK CONSUMPTION	132
10.7	SUMMARY	133
PART 11.	POTENTIAL DEMAND FOR PEAT PRODUCTS IN CANADA	135
11.1	INTRODUCTION	137
11.2	SURVEY METHODOLOGY	138
	1121 QUESTIONNAIRE DEVELOPMENT	139
11.3	PEAT COKE SURVEY RESULTS	139
	1131 CHEMICAL PRODUCERS	141
	1132 IRON, STEEL AND FERRO ALLOYS	142
	1133 MINING, SMELTING AND REFINING	143
11.4	ACTIVATED CARBON SURVEY RESULTS	144
	1141 BEVERAGE MANUFACTURERS	145
	1142 SUGAR MANUFACTURERS	147
	1143 OTHERS	148
11.5	PEAT TAR SURVEY RESULTS	149
11.6	PEAT WAX SURVEY RESULTS	150
11.7	SUMMARY	153
PART 12.	THE UNITED STATES AS A POTENTIAL MARKET FOR PEAT COKE AND ACTIVATED CARBON	157
12.1	INTRODUCTION	159
12.2	COKE PRODUCTION	159
	1221 COKE EXPORTS AND IMPORTS	159
	1222 COKE DISTRIBUTION	161
12.3	PROJECTION FOR COKE USAGE	162
12.4	ACTIVATED CARBON	163
12.5	SUMMARY	164
PART 13.	OTHER GEOGRAPHICAL AREAS AS POTENTIAL MARKETS FOR PEAT COKE	165
13.1	INTRODUCTION	167
13.2	WESTERN EUROPE	167

TABLE OF CONTENTS (Cont'd)

		PAGE
	1321 COKE CONSUMPTION	168
	1322 FINLAND	168
13.3	JAPAN	169
13.4	LATIN AMERICA	170
13.5	SUMMARY	172
PART 14.	CONCLUSIONS AND RECOMMENDATIONS	173
14.1	INTRODUCTION	175
14.2	RECOMMENDATIONS	181

APPENDICES

APPENDIX A	TERMS OF REFERENCE	183
APPENDIX B	ONTARIO RESEARCH FOUNDATION REPORT ON PEAT CHAR	187
1.	INTRODUCTION	190
2.	BACKGROUND	190
3.	DESCRIPTION OF MATERIALS USED	192
4.	DESCRIPTION OF PROCEDURES USED	194
5.	PREPARATION OF BRIQUETTES AND RESULTS	194
6.	CONCLUSIONS AND RECOMMENDATIONS	201
APPENDIX C	QUESTIONNAIRES	205
	COKE USERS QUESTIONNAIRE	207
	TAR USERS QUESTIONNAIRE	215
	ACTIVATED CARBON USERS QUESTIONNAIRE	218
APPENDIX D	OPERATING AND CAPITAL COSTS OF PEAT COKING PLANTS	223
APPENDIX E	LIST OF REFERENCES	233

LIST OF TABLES

2-1	Percentage of World Production, Trade and Consumption of 1980 World Figures for Coal Oven Coke for selected North American, European and Pacific Countries	11
2-2	Aggregate Coal Coke Data for the Exporting Nations which include U.K., Fed. Rep. of Germany, Italy and Japan	11
2-3	Aggregate Coal Coke Data for the Importing-Exporting Nations which include U.S.A., France, Belgium and the Netherlands	12

LIST OF TABLES (Cont'd)

		PAGE
2-4	Aggregate Coal Coke Data for the Importing Nations which include Austria, Brazil, Denmark, Finland, Luxembourg, Norway, Spain, Sweden and Switzerland	12
2-5	Aggregate Coal Coke Data for the Producers for Internal Use which include Australia, Canada, Greece and Portugal .	13
2-6	World Petroleum Coke Production	14
2-7	Blast Furnace Consumption of Coke in 1981	18
2-8	Production of Crude Steel	19
2-9	Direct Reduction Capacity in Operation, under Construction, or Planned in 1979	21
2-10	Petroleum Coke Quality Requirements	24
3-1	Estimated Activated Carbon Production	31
3-2	Sources for Activated Carbons in 1978	33
3-3	Variables Affecting the Production of Activated Carbon . . .	37
3-4	Estimated Use of Activated Carbons in 1982	38
4-1	Carbon Black Capacity	46
5-1	Characteristics of Peat and Montan Waxes	54
6-1	Production of Tars obtained from Coal, Lignite, Peat and Water Gas	59
6-2	Coal Chemicals	61
6-3	Peat Tars, Constituents and Uses in Russia	62
7-1	Characteristics of Finnish Sod Peat	71
7-2	Coke Specifications	75
7-3	Main Components of Ash	77
7-4	Physical Properties of Peat Coke	78
9-1	Cost Summary of Outokumpu Oy Process	103
9-2	Coke Prices in the U.S.A.	107
10-1	Canadian Coke Ovens and Blast Furnace Capacity as of January 1, 1983	114
10-2	Canadian Coal Coke Production	114
10-3	Use of Coal Coke in Canada	118
10-4	Non Blast Furnace Coke used in Iron and Steel Industry . . .	118
10-5	Coke Used by Industrial Chemical Producers	119
10-6	Petroleum Cokes	119
10-7	Geographical Distribution of Coke Consumers	121
10-8	Geographical Analysis of Steel Producers Capacity January, 1983	122
10-9	Geographical Distriution of Steel Coke Market based on 1983 Capacity of Electric Furnaces	122

LIST OF TABLES (Cont'd)

		PAGE
10-10	Foundry Coke Market Distribution Based on 1981 Consumption Data	123
10-11	Active Carbon Imports	126
10-12	Average Price for Activated Carbon in 1982	127
10-13	Activated Carbon Prices Historic Trend	127
10-14	Canadian Imports of Carnauba and Montan Waxes	131
10-15	Consumption of Carbon Black	133
11-1	Peat Coke Survey Summary	140
11-2	Activated Carbon Survey Summary	146
11-3	Summary of Number of Firms Contacted in Telephone Survey	151
11-4	Approximate Market Distribution of Montan and Carnauba Waxes	152
12-1	Coke Distribution from Coke Plants in 1982	161
12-2	Potential U.S.A. Metallurgical Coal Consumption	163
13-1	Finland Consumption of Coke	169
13-2	Latin America Production of Crude Steel Quantity in Million Tonnes	171
13-3	Coal Production, Use, Import and Export Projections for Metallurgic Coal Demand	171

LIST OF FIGURES

2-1	The Steel Making Process	16
2-2	Crude Steel Production	17
2-3	Petroleum Coke Markets	24
3-1	Alternative Processes to Produce Activated Carbon from Peat	35
4-1	United States Carbon Black Market Distribution	47
7-1	Dependence of the amount of volatiles on the degree of peat decomposition	68
7-2	Dependence of the carbon content of raw peat on the degree of decomposition	68
7-3	Dependence of the bending strength of sod peat on the degree of decomposition	69
7-4	Shrinkage of moulded peat	69
7-5	Resistance of sod peat to grinding	70
7-6	Material balance for the coking of medium-decomposed peat	73

LIST OF FIGURES (Cont'd)

		PAGE
7-7	Decomposition of peat organic mass 1-250°C, 2-200°C, 3-175°C, 4-125°C	73
7-8	The effect of heating rate on coke yield	74
7-9	Relative electric resistance of coke grades as function of temperature. Particle size 10-20 mm	79
7-10	Blast Furnace Coke Requirements	81
7-11	Cupola Coke Requirements	83
8-1	Process Flowchart of the Peat Coke Factory at Vapo Oy	88
8-2	Outokumpu Oy Material Balance	88
8-3	The process flowchart of the peat coke factory at Elizabethfehn, Oldenburg, F.R.G.	92
8-4	The material balance of the process of peat coke factory at Elisabethfehn	92
8-5	The process flowchart of a hearth oven equipped with the recovery of waste heat	94
8-6	The process flowchart of the Lurgi-Spuhlgas process	97
12-1	Coke Production, Imports, Consumption, Exports and Stocks	160

EXECUTIVE SUMMARY

An estimate of the potential demand for peat carbon products is developed by analysing information collected through a literature review, telephone and mail surveys, and field visits to current carbon product users. The objectives of the study are:

- a global survey of existing commercial operations to provide information on both technical details and production costs;

- a survey of processes under development including a technical assessment of their feasibility;

- an analysis of Canadian and global market conditions with respect to the potential of these products for both the domestic and export markets;

- a rating of the identified processes with respect to their economic viability in Canada;

- recommendations for a research strategy designed to improve the economic feasibility of one or more of these processes in Canada.

METHODOLOGY AND FINDINGS

The products investigated; some of their relevant characteristics and promising applications are summarized below:

Peat Products	Characteristics	Applications
Coke	- very reactive[1] - low strength[1] - low sulphur[1],[2]	- reducing agent in electric furnaces
activated carbons	- high volatile content[1] can increase manufacturing costs - all grades can be produced from peat	- survey revealed no area where peat based activated carbons offered processing advantages
tars	- mainly aliphatic components unlike aromatic coal tar components	- further research needed to identify components and extend areas of use
waxes	- similar to montan and carnauba waxes	- further research needed to identify components and extend areas of use
carbon black	- need aromatic feedstock	- the use of aliphatic peat tar not considered technically feasible at present

The properties of peat coke make it well suited for use as a reducing agent in electric furnaces. An increased use of electric furnaces, particularly in the steel industry, is forecasted. Currently coal cokes and petroleum cokes compete for use in electric furnace applications.

---

[1] As compared to coal products.

[2] Depends on peat bog selection.

The steel industry's blast furnaces consume most of the coal coke. Currently, reduced demand for coal coke is a result of cutbacks in steel production and a decreased use of blast furnaces. This increases the supply of coal coke available for use in electric furnaces.

Eighty percent of the world's petroleum coke is produced in the United States. The major market for these cokes is the aluminum industry for anode production. Reduced demand for petroleum coke by the aluminum industry increases the supply available for use in electric furnaces.

The non-communist production of activated carbon is concentrated in the United States and Western Europe. Current production levels are estimated to be approximately 60-70% of capacity. Peat can be used to manufacture all grades of activated carbons and is currently used by one European manufacturer, Norit N.V., located in the Netherlands.

The carbon black industry can be described as stable or mature, possibly in decline. Currently, ninety five percent of carbon black is consumed in the rubber industry. Investigations during this study have determined that peat tars are not suitable as feedstock for carbon black production.

Peat wax is compared in the literature to montan and carnauba waxes. Unless unique properties of peat waxes are identified which will benefit users, peat will not be able to compete with the lower priced montan waxes.

Peat tar constituents are not well known at this time. They appear to have a closer resemblance to petroleum tars than to coal tars. The lack of information available on the characteristics prevented a meaningful assessment of the market potential of peat tar.

Two peat coking operations, Wielandt and Outokumpu Oy, and two processes that have been proposed as suitable, Lurgi-Salem and Lurgi Spuhlgas, were examined. Material balances and operating descriptions were supplied by the Technical Research Centre of Finland (VTT). All factors from bog selection, peat extraction, drying, and coking affect the final product.

The Ontario Research Foundation (ORF) performed exploratory tests to determine the feasibility of using peat coke in combination with a low cost binder system for use as foundry coke. Laboratory results were inconclusive but it is judged that further research is warranted.

A brief economic analysis of peat coke, based on VTT estimates of production costs and Monenco estimates of sod peat mining costs, indicate that minimum capital subsidies ranging from $7 to $22 million of the total estimated capitalized cost ($21 to $40 million) are required to bring the capital and operating cost recovery price of peat in line with current prices for industrial coal coke ($140/tonne). This analysis also indicated that peat coke obtained from the Outokumpu Oy process has the lowest anticipated capital and operating costs ($180-$260/tonne). Expected revenues from the sale of process by products, power and briquettes, could effectively reduce peat coke costs, thus the addition of power and briquette modules to the plants might provide positive benefits. However, a market survey for the power and briquette products was not conducted.

A detailed analysis of current Canadian carbon product users, based on Statistics Canada data was carried out. A questionnaire, developed as a result of visits to 3 coke users, 3 activated carbon users and 2 tar users, was sent out to a sample of industrial users in order to determine current specifications and quantities consumed of these products. A telephone survey of industrial wax users and suppliers provided data for projecting potential consumption of peat

waxes. Based on this information, an estimate of the potential demand for peat products in Canada was developed.

POTENTIAL DEMAND IN CANADA

Assuming that capital subsidies can be provided to reduce the price of peat coke to competitive levels, its potential demand is defined as that which could develop during a slow but steady economic recovery, in applications that are technically feasible and will at least be considered for commercial use in the next five years. The potential demand for peat coke is shown below.

Estimated Potential Peat Coke Demand

Industry	Quantity (kilotonnes/year)
Chemical	180
Ferro-alloys	105
Mining and smelting	15
	300

These figures must be used given the following limitations:

1) 14 coke users supplied data by completing the questionnaires.

2) The start of peat production can require up to 6 years of peat bog development.

3) Suitable peat bogs would have to be identified. Users are concentrated in Quebec and Ontario with a chemical manufacturer located in Newfoundland.

4) The coke that peat would be replacing is a screened by-product of blast furnace coal coke. Almost all of this coke is currently imported.

The Canadian market for activated carbon can be described as mature since current annual demand (5.2 kilotonnes) has remained virtually constant since 1978. The only interest in peat activated carbons was indicated by the sugar producers. This is attributed to the extensive use of activated carbon in the sugar industry and the unique operating requirements imposed by mixing "in-house" manufactured activated carbons with commercial activated carbons. However, there was no evidence that peat-based activated carbons would be more suitable than other feedstocks for this application. In addition, the unit cost of activated carbon used is less than the national average ($0.62/kg versus $1.62/kg in 1982). The market potential for peat activated carbons is therefore considered to be low in this application.

It was determined that there is no market potential for peat based waxes or tars in Canadian industry.

EXPORT POTENTIAL

There is a maximum potential market of 1 million short tons for peat coke in the U.S. Relatively lower prices for coal coke in the U.S. (the source of Canadian cokes) would put peat coke at a significant disadvantage. Large growth in activated carbon demand will depend on use of carbons in the water resource industry. Current controversy between the Environmental Protection Agency and the water resource utilities will have to be resolved. Until then, excess capacity in the U.S. activated carbon industry may continue.

Japan, as an importer of Canadian coking coals, could be considered as a potential market for peat coke. The most promising developing area is possibly Latin America, where rapid growth in the steel industry is currently taking place.

CONCLUSIONS

The use of peat cokes as a reducing agent is a promising application. However, the cokes that peat cokes would replace are by-products. Supply of these by-products is insensitive to demand, with market equilibrium maintained by price adjustment. This increases the risk of peat coke production as:

- prices of petroleum and screened blast furnace coke depend on activity in unrelated or loosely related industries;

- supply of these products would continue even after the price falls below the breakeven point for peat coke. Thus increased efficiencies in peat coke manufacture provide no assurance of long term survival.

Capital subsidies would be required to bring the capital and operating cost recovery price of peat coke in line with screened coal coke. As most of the cokes currently being used originate in the U.S., the benefits of import substitution may justify the subsidies.

The domestic activated carbon market is too small and segmented to support a peat-based activated carbon manufacturer. As the survey revealed no areas where peat activated carbons offered operating advantages and current suppliers enjoy existing economies of scale resulting from servicing large domestic markets, we cannot justify establishing a domestic peat-based activated carbon manufacturer.

RECOMMENDATIONS

- Upgrading peat through coking is not considered practical at this time as peat coke is too expensive when compared to alternate cokes.

- An economic analysis is required to investigate whether capital subsidies can be justified based on the benefits of import substitution.

- If capital subsidies are justified then suitable peat bogs possibly close to the Quebec ferro-alloy producers should be located. Tests with coke produced from an Outokumpu Oy process should be conducted with these producers.

- Research investigating the feasibility of manufacturing foundry coke from peat coke would be justified as foundry coke commands a price premium and is imported. This research, following on the results of the Ontario Research Foundation exploratory investigation, should address:

  - minimum temperature to remove at least 90-95% of the volatile content of peat char
  - form briquettes using low cost binders
  - conduct reactivity tests to estimate relative consumption of peat coke in the production of cast iron.

- Although present market sizes would not justify the significant cost of research identifying the components of peat waxes and peat tars, this research may well open up new market opportunities.

RÉSUMÉ À L'INTENTION DE LA DIRECTION

On prépare actuellement une estimation de la demande potentielle de produits carbonés dérivés de la tourbe, en analysant l'information connue, au moyen d'un examen d'ensemble de la documentation scientifique, d'enquêtes conduites par téléphone et par la poste, et de rencontres avec des utilisateurs actuels des produits en question. Les objectifs de l'étude sont :

- une vue d'ensemble des opérations commerciales existantes, pour obtenir de l'information sur les détails techniques et les coûts de production;

- l'examen des procédés actuellement élaborés, y compris une évaluation technique de leur applicabilité;

- une analyse des marchés canadiens et mondiaux, pour connaître le potentiel de commercialisation de ces produits sur le marché domestique et les marchés extérieurs;

- une évaluation des procédés identifiés, quant à leur viabilité économique au Canada;

- des recommandations concernant une stratégie de la recherche, dans le but d'améliorer les perspectives économiques de l'un ou de plusieurs de ces procédés au Canada.

MÉTHODES ET CONSTATATIONS

Produits étudiés; quelques-uns de leurs caractères pertinents et de leurs applications intéressantes sont résumés ci-dessous :

Produit dérivés de la tourbe	Caractéristiques	Applications
Coke	- très réactif[1] - faible résistance mécanique[1] - faible taux de soufre[1,2]	- agent réducteur dans les fours électriques
Charbons actifs	- forte teneur en produits volatils[1] d'où une augmentation possible des dépenses de production - toutes les qualités peuvent être obtenues à partir de la tourbe	- l'étude n'a révélé aucun secteur dans lequel les charbons actifs dérivés de la tourbe offrent des avantages du point de vue de leur traitement
Goudrons	- ce sont principalement des composés aliphatiques différents des composés aromatiques des goudrons de houille	- d'autres recherches sont nécessaires pour en identifier les composants, et leur trouver une plus grande gamme d'usages
Cires	- semblables aux cires de lignite, et aux cires de type carnauba	- d'autres recherches sont nécessaires pour en identifier les composants, et leur trouver une plus vast gamme d'usages
Carbon black	- nécessite une matière première aromatique	- l'utilisation de goudron de tourbe alipha tique n'est pas consi déré comme technique-ment faisable actuellement

[1]Par comparaison avec les produits houillers
[2]Dépend de la tourbière choisie pour l'exploitation

Les propriétés du coke de tourbe en font un excellent agent réducteur dans les fours électriques. On prévoit une utilisation accrue des fours électriques, surtout dans les aciéries. Actuellement, on utilise autant les cokes de charbon que les cokes de pétrole dans les fours électriques.

Les hauts fourneaux des aciéries consomment la majeure partie du coke houiller. Actuellement, la diminution de la demande de coke de charbon est due à des réductions de la production de l'acier et de l'utilisation des hauts fourneaux. D'où l'accroissement des fournitures de coke de charbon destiné aux fours électriques.

Quatre-vingt pour cent du coke de pétrole employé dans le monde provient des États-Unis. Le principal marché pour ce type de coke est l'industrie de l'aluminium, pour la fabrication d'anodes. La diminution de la demande de coke de pétrole par l'industrie de l'aluminium augmente les réserves disponibles de ce produit pour les fours électriques.

Dans les pays non communistes, la production de charbon actif se concentre aux États-Unis et en Europe de l'Ouest. On estime que les taux actuels de production se situent à environ 60-70 % de la capacité de production. On peut utiliser la tourbe pour fabriquer toutes les qualités de charbon actif; un fabricant européen, la Norit N.V., installée aux Pays-Bas, emploie actuellement ce produit.

On peut décrire l'industrie du carbon black comme stable ou parvenue à maturité, ou peut-être même déclin. L'industrie des caoutchoucs consomme aujourd'hui quatre-vingt quinze pour cent du carbon black. Les enquêtes faites dans le cadre de cette étude ont montré que les goudrons de tourbe ne sont pas une matière première convenant à la fabrication du carbon black.

Dans la documentation scientifique, les cires de tourbe sont comparées aux cires de lignite et aux cires de type carnauba. A moins que l'on ne trouve aux cires de tourbe des propriétés uniques, dont puissent profiter les utilisateurs éventuels, la tourbe ne pourra concurrencer les cires de lignite moins coûteuses.

Pour l'instant, on connaît mal les constituants du goudron de tourbe. Il semble qu'ils se rapprochent davantage des goudrons de pétrole que des goudrons de houille. Il est difficile d'évaluer le potentiel de commercialisation des goudrons de tourbe, étant donné l'absence d'information sur les caractéristiques de ce produit.

On a étudié la fabrication du coke de tourbe dans deux installations, les usines Wielandt et Outokumpu Oy, et examiné deux méthodes proposées et jugées appropriées, les procédés Lurgi-Salem et Lurgi Spuhlgas. Le Centre de recherches techniques de la Finlande (Technical Research Centre of Finland, VTT) a fourni des descriptions des balances de matériel et de l'exploitation. Tous les facteurs, depuis le choix de la tourbière, les procédés d'extraction, de séchage et de cokéfaction de la tourbe, ont une influence sur le produit final.

L'Ontario Research Foundation (ORF) a effectué des expériences pour déterminer la possibilité d'utiliser le coke de tourbe conjointement à un produit agglomérant de faible coût, pour donner du coke de fonderie. Les résultats des expériences en laboratoire étaient peu concluants, mais on estime que des recherches plus poussées sont justifiées.

Une brève analyse de la rentabilité économique du coke de tourbe, fondée sur les estimations de la VTT concernant les coûts de production et sur les estimations de la Monenco concernant les coûts d'extraction de la tourbe fraîche, indiquent qu'il faudrait au minimum des subventions représentant $ 7 à $ 22 millions du coût capitalisé total estimé ($ 21 à $ 40 millions), pour aligner les coûts en capital

et l'amortissement des frais d'exploitation du coke de tourbe, avec les prix actuels du coke de charbon industriel ($ 140/tonne). Cette analyse a aussi montré que le coke de tourbe obtenu avec le procédé employé par l'usine Outokumpu Oy exigeait les plus faibles coûts en capital et coûts d'exploitation prévus ($ 180 - $ 260/tonne); en outre, les recettes espérées de la vente des sous-produits, de l'électricité et des briquettes permettraient sans doute de réduire le coût du coke de tourbe; donc l'installation dans les usines de modules produisant de l'électricité et des briquettes, pourrait être économiquement rentable. Toutefois, une étude des marchés éventuels de l'électricité et des briquettes n'a pas été faite.

on a réalisé une analyse détaillée relative aux utilisateurs canadiens actuels de produits carbonés, d'après des données fournies par Statistiques Canada. On a expédié à un échantillonnage de consommateurs de l'industrie un questionnaire, élaboré à la suite de visites chez trois utilisateurs de coke, trois utilisateurs de charbon actif, et deux utilisateurs de goudron, afin de déterminer les spécifications actuelles relatives à ces produits et les quantités consommées de ceux-ci. Une enquête téléphonique auprès des utilisateurs et fournisseurs de cires industrielles a fourni les données en fonction desquelles on a estimé la consommation potentielle de cires de tourbe. Grâce à cette information, on a produit une estimation de la demande éventuelle de produits dérivés de la tourbe au Canada.

DEMANDE POTENTIELLE AU CANADA

En admettant que l'on puisse obtenir des subventions qui permettent d'abaisser le prix du coke de tourbe à des niveaux compétitifs, on définit la demande potentielle de ce produit comme celle qui pourrait se manifester durant une remontée économique lente mais continue; il s'agirait d'applications techniquement réalisables, et qui dans un délai minimum de cinq ans, offrent des perspectives de commercialisation. La demande potentielle de coke de tourbe est indiquée ci-dessous.

Demande potentielle estimée de coke de tourbe

Industrie	Quantités (kilotonnes/année)
Produits chimiques	180
Ferro-alliages	105
Exploitation minière et traitement des minerals	
	300

On doit utiliser ces chiffres avec les restrictions suivantes :

1) 14 utilisateurs de coke ont fourni les données en complétant les questionnaires.

2) Le démarrage de la production de tourbe peut demander jusqu'à 6 ans de préparation de la tourbière.

3) On doit identifier les tourbières appropriées. Les utilisateurs sont concentrés au Québec and en Ontario; un fabricant de produits chimiques se trouve à Terre-Neuve.

4) Le coke que la tourbe doit remplacer est un sous-produit, épuré par tamisage, du coke de charbon pour hauts-fourneaux. La presque totalité de ce coke est actullement importée.

On peut décrire le marché canadien du charbon actif comme parvenu à maturité, puisque la demande annuelle (5,2 kilotonnes) est virtuellement constante depuis 1978. Seuls les producteurs de sucre ont manifesté un intérêt pour les charbons actifs dérivés de la tourbe. La raison en est l'emploi intensif du charbon actif par l'industrie du sucre, ainsi que les exigences uniques de l'exploitation, imposées par le mélange de charbons actifs manufacturés sur place avec les charbons

actifs vendus dans le commerce. Toutefois, il n'est pas prouvé que lescharbons actifs à base de tourbe conviennent mieux que d'autres matières premières à ce type d'application. En outre, le coût unitaire du charbon actif utilisé est moindre que le coût moyen de ce type de charbon au Canada ($ 0,62/kg vis-à-vis de $ 1,62/kg en 1982). On considère donc le potentiel de commercialisation des charbons actifs dérivés de la tourbe comme faible à cet égard.

On a déterminé que dans l'industrie canadienne, la commercialisation des cires ou goudrons de tourbe était sans intérêt.

POTENTIEL D'EXPORTATION

Il existe aux États-Unis un marché potentiel maximum d'un million de tonnes courtes pour le coke de tourbe. Les prix relativement bas du coke de charbon aux États-Unis (la source des cokes canadiens) font que le coke de tourbe se trouve nettement désavantagé. Une croissance importance de la demande de charbon actif dépendra de l'utilisation de ce type de charbon par l'industrie des ressources hydrologiques. Il faudra que soit résolu le conflit actuel entre l'Agence de la protection de l'environnement (Environmental Protection Agency) et les compagnies d'hydroélectricité. Jusque là, l'industrie américaine du charbon actif aura sans doute une capacité excédentaire.

Le Japon, étant un importateur de charbon gras canadiens, peut être considéré comme un marché potentiel du coke de tourbe. Le secteur le plus prometteur est sans doute l'Amérique Latine, où l'on observe actuellement une croissance rapide des aciéries.

CONCLUSIONS

L'utilisation des cokes de tourbe comme agents réducteurs est une application d'avenir. Toutefois, les cokes que remplacerait le coke de tourbe sont des sous-produits. La fourniture de ces sous-

produits n'est pas dépendante de la demande, et l'équilibre du marché est assuré par des ajustements de prix. Il en résulte les risques suivants pour la production de coke de tourbe :

- les prix du coke de pétrole et des cokes épurés de haut fourneau dépendent des activités d'industries sans rapport avec le secteur minier, ou presque indépendantes de celui-ci;

- la fourniture de ces produits continuerait même après la chute des prix au-dessous du seuil de rentabilité du coke de tourbe. Ainsi, un rendement accru de la fabrication du coke de tourbe n'assure en aucune manière la survie à long terme de cette industrie.

Il faudrait des subventions pour aligner les coûts en capital et l'amortissement des frais d'exploitation, avec le coût du coke de charbon épuré. La plupart des cokes actuellement utilisés provenant des États-Unis, les bénéfices qui résultent du remplacement des importations peuvent justifier les subventions accordées.

Le marché domestique du charbon actif est trop restreint et fragmenté pour assurer la rentabilité d'une industrie de fabrication de charbon actif à base de tourbe. L'enquête n'ayant révélé aucun secteur où ces charbons actifs à base de tourbe soient avantageux du point de vue de leur utilisation, et où les fournisseurs actuels tirent des bénéfices substantiels en desservant de vastes marchés domestiques, nous ne pouvons justifier l'établissement d'une industrie de fabrication domestique des charbons actifs à base de tourbe.

RECOMMANDATIONS

- Pour l'instant, on ne considère pas comme pratique la valorisation de la tourbe par cokéfaction, le coke de tourbe étant trop cher par rapport aux autres types de coke.

- Une analyse de rentabilité économique est indispensable pour indiquer si des subventions se justifient, par les bénéfices résultant du remplacement des importations.

- Si les subventions se justifient, on doit rechercher des tourbières appropriées, si possible proches des producteurs québécois de ferro-alliages. On doit effectuer, conjointement à ces producteurs, des essais sur les cokes fabriqués par l'un des procédés de l'usine Outokumpu Oy.

- Des recherches se justifient, sur la faisabilité des procédés de fabrication du coke de fonderie à partir des cokes de tourbe, puisque le coke de fonderie se vend à prix élévé et qu'il est importé. La recherche, d'après les résultats de l'étude préliminaire de l'Ontario Research Foundation, doit porter sur les détails suivants :

  - la température minimale permettant d'éliminer au moins 90 à 95 % des produits volatils des charbons de tourbe.

  - le moulage de briquettes à l'aide de liants peu coûteux.

  - la réalisation d'essais de réactivité, permettant d'estimer la consommation relative de coke de tourbe pour la production de fonte.

- Bien qu'actuellement, la dimension du marché ne justifie par le coût élevé de la recherche sur la détermination des composants des cires et goudrons de tourbe, cette recherche nous permettra peut-être de trouver de nouvelles possibilités de commercialisation.

PART 1

INTRODUCTION

1.1 INTRODUCTION

In late June 1983, the Department of Supply and Services Canada issued a request for proposals for a study to be titled "Carbon Products from Peat". Montreal Engineering Company Ltd. submitted a proposal which responded to the Terms of Reference (TOR) on August 5, 1983 (see Appendix A). The proposal was accepted and a contract, DSS file number 02SX.31926-3-0130 was signed in November 1983.

1.2 TERMS OF REFERENCE

The Terms of Reference are attached as Appendix A. The objectives of the study specified in the TOR are:

- a global survey of existing commercial operations to provide information on both technical details and production costs;
- a survey of processes under development including a technical assessment of their feasibility;
- an analysis of Canadian and global market conditions with respect to the potential of these products for both the domestic and export markets;
- a rating of the identified processes with respect to their economic viability in Canada;
- recommendations for a research strategy designed to improve the economic feasibility of one or more of these processes in Canada.

This study has been prepared to meet these objectives. The methods of approach and presentation are discussed in Section 1.3.

1.3 APPROACH AND PRESENTATION

The first phase of the project was an extensive literature review on the current global production and consumption of coke, activated carbon, carbon black, waxes and tars. United Nations, O.E.C.D., Predicast data banks, Statistics Canada, U.S. energy information administration, and other reference sources (detailed in Appendix E) supplied the information that is presented in Parts 2 through 6. Information supplied by the Technical Research Centre of Finland (VTT) dealing with the preparation of peat activated carbon is also included in Part 3.

Parts 2 through 6 provide the background for a complete understanding of the characteristics of activated carbons, carbon black, waxes and tars and their global markets. These parts may not be of interest to all readers, and are not prerequisite for an understanding of the following sections.

Information supplied by VTT and the Ontario Research Foundation (ORF) is presented in Part 7 which details the factors affecting peat coke preparation and the characteristics of peat coke. The full ORF report is included as Appendix B. An analysis of the applications of peat coke from a technical viewpoint is also presented.

Information on the current production processes in Europe and the status of processes currently under development for manufacturing peat coke was supplied by VTT. This information is presented in Part 8.

In Part 9, the current capital and operating cost estimates for coking facilities obtained by VTT are combined with Monenco's estimated costs of mining sod peat in Canada. The capital and operating cost recovery price of peat coke is developed and the minimum capital subsidies required to bring peat coke prices in line with competing cokes are developed. Appendix D includes cost summary sheets.

Part 10 presents a summary of current statistics for Canadian consumers and producers of carbon products. Companies and industries identified by Statistics Canada and other sources as carbon product users are presented. A summary of the carbon black market is also presented, although the use of peat as a feedstock is not considered feasible at this time.

An analysis of the potential markets in Canada for peat carbon products based on the survey that was conducted is given in Part 11. Information was obtained from coke, activated carbon and tar users across Canada by means of mail questionnaires. In developing the questionnaires, several plant visits to Ontario consumers were conducted in order to obtain feedback (complete questionnaires are included in Appendix C). In areas where a low response was encountered, users were contacted by telephone. A telephone survey was used to contact potential peat wax users, limited to Ontario and Quebec companies.

Part 12 presents information related to the United States as a potential market for peat coke and activated carbon.

Forecasts for the countries identified as coke importing nations in Part 2 are presented in Part 13. Data for Japan are also presented, due to its status as an importer of coking coal from Canada.

Part 14, Conclusions and Recommendations, presents a summary of the study and suggests areas of further involvement and analysis in determining the feasibility of carbonized peat products.

PART 2

PRODUCTION AND CONSUMPTION OF COKE

2.1 INTRODUCTION

This section examines the global production and consumption of both coal and petroleum cokes. Countries are grouped and classified as exporting nations, exporting-importing nations, importing nations, and producers for internal use.

Current uses of cokes, particularly in the steel industry, are outlined. Recent and future consumption trends are highlighted where they are deemed relevant to the study.

2.2 GLOBAL PRODUCTION STATISTICS

221 COAL COKE

Coal cokes are classified as either low-temperature or high-temperature coke. High-temperature cokes are generally called metallurgical cokes and are primarily used in the steel industry. Low-temperature cokes are by-products of coal gas, fuel, and chemical feedstock production, and are used as 'smokeless' solid fuels. These low-temperature cokes have largely disappeared since oil and natural gas have become widely available./17/ This section deals with production, trade and consumption of the high-temperature cokes.[1]

Selected North American, European and Pacific countries have been grouped into four categories according to their coke usage. These categories are described below:

[1] Data includes coke breeze.

- EXPORTING NATIONS (See Table 2-2). These countries are net exporters and account for over 48 percent of the 1980 exports of coal oven coke. They also represent over 25 percent of the 1980 World production.

- IMPORTING-EXPORTING NATIONS (See Table 2-3). These countries, whilst collective importers, also export over 14 percent of the 1980 world trade in oven coke.

- IMPORTING NATIONS (See Table 2-4). These countries are all net importers, with imports exceeding 100,000 metric tonnes of coal oven coke per year. They account for nearly 30 percent of the 1980 world imports in coal oven coke, although only representing 4.8 percent of the 1980 world consumption.

- PRODUCERS FOR INTERNAL USE (See Table 2-5). These nations are characterized as having very low imports and exports of coal oven coke. Most of their production, which accounts for just over 3 percent of world production, is consumed internally.

The aggregated data for these groups is shown in Table 2-1 and represents the percentage of world production, trade and consumption of coke for each group.

TABLE 2-1

Percentage of World Production, Trade and Consumption of 1980 World Figures for Coal Oven Coke for Selected North American, European and Pacific Countries

(Percent)

Groups	Production	Imports	Exports	Consumption
Exporting Nations	25.3	5.2	48.3	22.7
Importing-Exporting Nations	19.6	21.9	14.6	20.4
Importing Nations	3.0	29.2	0.6	4.8
Producers for Internal Use	3.1	0.6	0.9	3.1
Others	49.0	43.1	35.6	49.0
TOTAL	100.0	100.0	100.0	100.0

NOTE: This table is a summary of Tables 2-2 through 2-5.

SOURCE: /15/.

TABLE 2-2

Aggregate Coal Coke Data for the Exporting Nations Which Include U.K., Fed. Rep. of Germany, Italy and Japan

(Quantity in kilotonnes)

Year	Production	Imports	Exports	Changes in Stocks	Consumption
1976	99,121	1,558	9,171	1,792	89,716
1977	96,749	1,287	8,144	3,717	86,175
1978	89,190	1,113	10,447	-2,816	82,672
1979	92,537	1,429	14,502	-11,667	91,131
1980	97,284	1,275	11,403	-1,366	88,522

NOTE: Germany in 1978 accounted for: 75 percent of the exports and 83 percent of the imports.

SOURCE: /15/.

TABLE 2-3

Aggregate Coal Coke Data for the Importing - Exporting Nations Which Include U.S.A., France, Belgium, and the Netherlands

Quantity in kilotonnes

Year	Production	Imports	Exports	Changes in Stocks	Consumption
1976	77,080	4,648	3,262	1,713	76,753
1977	75,515	4,368	3,027	-69	76,925
1978	66,910	7,982	2,327	-2,669	75,234
1979	83,589	8,194	4,623	591	86,567
1980	75,305	5,406	3,451	-2,331	79,591

SOURCE: /15/.

TABLE 2-4

Aggregate Coal Coke Data for the Importing Nations Which Include Austria, Brazil, Denmark, Finland, Luxemburg, Norway, Spain, Sweden and Switzerland

Quantity in kilotonnes

Year	Production	Imports	Exports	Changes in Stocks	Consumption
1976	10,207	6,396	134	351	16,118
1977	10,377	5,314	173	-106	15,624
1978	10,284	5,589	264	-295	15,904
1979	10,821	7,093	87	34	17,793
1980	11,589	7,190	153	33	18,593

NOTE:
- In 1978 Spain & Brazil accounted for 74% of production.
- Sweden, Norway & Austria only countries that export.
- In 1978 Austria, Finland, and Luxembourg accounted for 70% of imports.
- Denmark, Finland, Luxembourg and Switzerland are totally reliant on imports for their consumption.

SOURCE: /15/.

TABLE 2-5

Aggregate Coal Coke Data for the Producers for Internal Use Which Include Australia, Canada, Greece and Portugal

Quantity in kilotonnes

Year	Production	Imports	Exports	Changes in Stocks	Consumption
1976	12,825	387	431	-62	12,843
1977	11,714	557	200	30	12,041
1978	11,656	743	358	19	12,022
1979	12,786	576	369	315	12,678
1980	11,986	160	220	-64	11,990

NOTE: In 1978, Canada accounted for: 43% of production
74% of imports
61% of exports
44% of consumption

SOURCE: /15/.

222 PETROLEUM COKE

The production of petroleum coke is summarized in Table 2-6.

The United States is the largest producer of petroleum coke accounting for over 80% of 1980 world production. In 1980, approximately 67% of the total coke produced in the U.S.A. was exported./1/

TABLE 2-6

World Petroleum Coke Production

Quantity in kilotonnes

Countries	1976	1978	1980
U.S.A.	23,614	24,418	24,098
Canada	651	972	977
Japan	208	157	254
W. Europe	938	2,164	1,910
World	27,772	30,391	29,879

SOURCE: /15/.

223 FEEDSTOCKS FOR COKE

The two major types of coke, coal based and petroleum based, have special feedstock requirements, which are described in Sections .1 and .2.

.1 Coal Coke

The literature indicates that the properties of coke are strongly dependant upon the quality of coal used and the temperature at which it is carbonized. It is generally agreed that the most desirable blast furnace coke is currently made from mixtures of high-volatile and low-volatile coals./2/12/17/

Coals are selected and blended to meet the coke users' requirements. The ash content, ash composition, calorific values,

volatile matter and sulphur content appear to be important parameters. Empirical relationships between plasticity, stability, reactivity and blend composition exist for most coals./2/

Low sulphur coals are becoming more scarce, and coke manufacturers are relying on various methods of coal preparation to reduce sulphur percentage. In the United States the average sulphur percent for metallurgical coals was 0.9% in 1982./3/ This value is close to the limits identified for many users. (See Section 7.3)

.2 Petroleum Coke

Petroleum coke is a by-product produced from processes designed to maximize the quantity of light refined products from crude oil. Consequently the supply of coke is highly inelastic with respect to its price.

Special markets have developed that require certain coke properties and exhibit different demand and pricing characteristics. The higher valued markets are limited to cokes with low sulphur and low metals content. These are the aluminum anode and to a lesser extent the metallurgical coke markets. It is estimated that the average sulphur will increase from approximately 2-1/2 percent to 4-1/2 percent by 1990./1/ This may increase coke prices in premium markets by limiting supply.

2.3 USES OF COKE

231 STEEL INDUSTRY

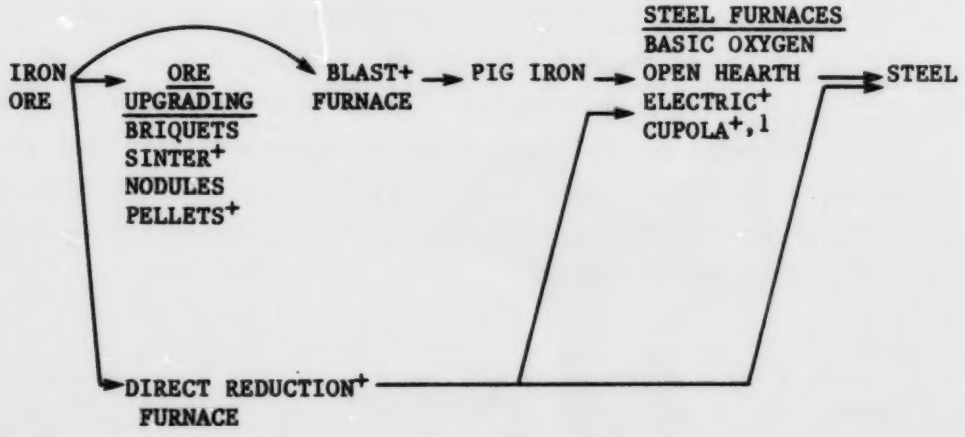
The steel industry is the largest user of coal coke, the majority of which is consumed in the blast furnaces. The processing

of iron ore into steel can follow several routes (see Figure 2-1: The steel making process). Coke can be used at several stages, which have been identified in Figure 2-1.

The steel industry has been in a steady decline since 1979. (See Figure 2-2)./4/5/6/ The industry is characterized by a global surplus and extreme price competition. The increased demand for protectionism in the forms of tariffs and quotas are witnessed in most developed countries. Both the U.S.A. and the EEC have announced tariffs and quotas on some items./7/8/9/10/ The EEC has called for capacity cuts of about 35 million tonnes annual capacity by 1985, yet excess capacity is still forecast to be over 50 million tonnes in 1985.

FIGURE 2-1

The Steel Making Process

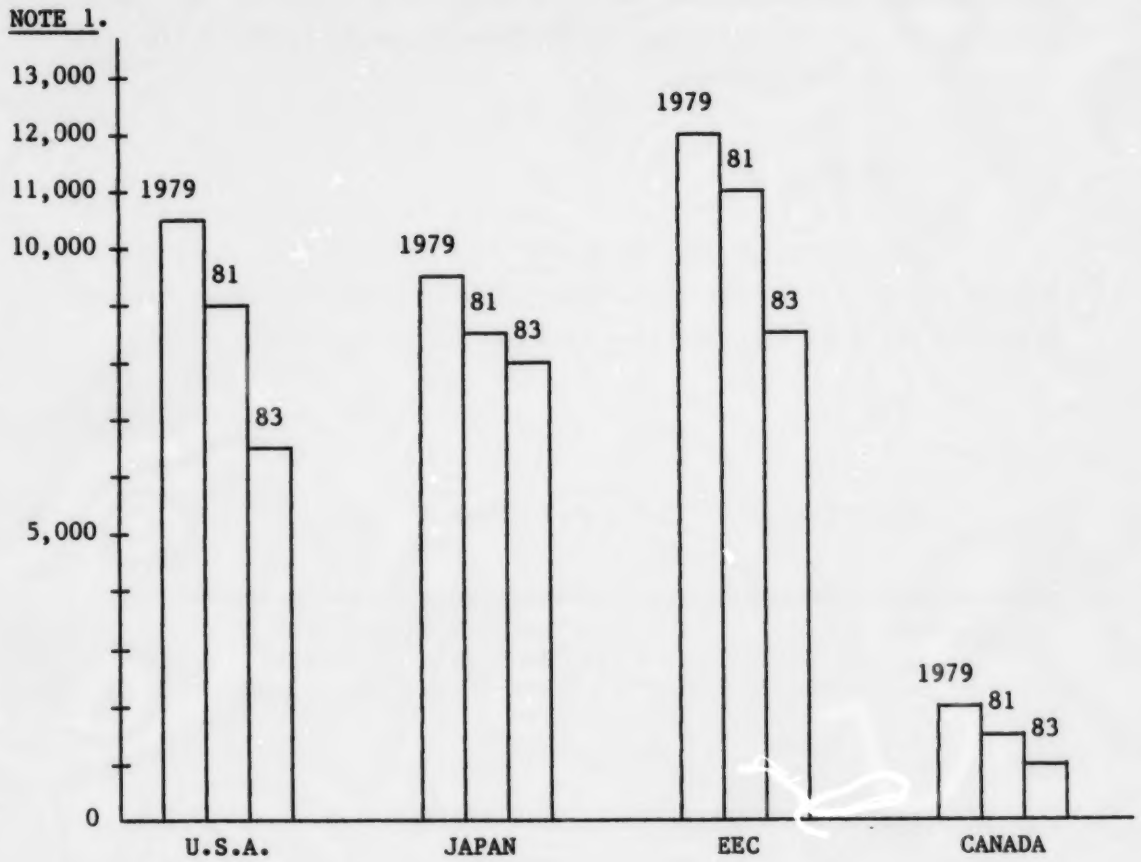


+ Coke may be used at this stage in the process. 1

1 Cupolas are used primarily for iron castings.

FIGURE 2-2

Crude Steel Production



NOTE 1: Monthly Average Quantity in kilotonnes.
Year ends on July of year noted.

SOURCE: /16/.

The economic recovery which started in the U.S.A. in early 1983 slowly spread to the EEC and Japan in the fourth quarter of 1983. The pronounced recovery of the automotive industry and strengthening demand for appliances has increased steel demand for flat rolled, bar and wire products. However, heavy construction is still in a recession and this severely reduces demand for pipe, plate

and structurals. Consequently, Western world steel demand is forecast to grow 6 percent in 1984 with Global steel consumption forecast to improve 3 to 4 percent in 1984./2/11/ For the balance of the decade Western world consumption is unlikely to grow more than 1% per year. These trends will be reflected in the demand for coke, which can also expect to have little growth.

.1 Blast Furnaces

Blast furnaces, which produce iron from iron ore, are the largest consumers of coal coke, especially in North America. See Table 2-7 for 1981 blast furnace consumption of coal coke.

TABLE 2-7

Blast Furnace Consumption of Coke in 1981

Country	% of Total Consumption of Coke Used in Blast Furnaces in 1981
Canada	91
USA	93
Western Europe	88
Japan	87

NOTE: Countries included in Western Europe are:

Germany	Luxembourg	Norway
Belgium	Netherlands	Portugal
Denmark	United Kingdom	Sweden
France	Austria	Turkey
Greece	Spain	
Italy	Finland	

SOURCES: Statistics Canada Catalogue 45-002, December 1982 /18/19/

For every tonne of iron ore produced, between 0.5 and 0.65 tonnes of coke are consumed./12/ This amount is constantly decreasing as blast furnaces become more efficient.[1] The coke provides the heat required for smelting and also the chemical reactants (primarily carbon monoxide) for reducing iron ore. In addition, it supplies the carbon that dissolves in the hot metal (about 33 to 40 kg per tonne of pig iron).

.2 Steel Production Furnaces

There are three major furnaces used in the production of steel: basic oxygen, open hearth and electric. For the relative importance of these see Table 2-8: Production of Crude Steel. As can be seen, electric furnaces currently account for between 20 to 30

TABLE 2-8

Production of Crude Steel

Country	Type of Furnace			Total
	Basic Oxygen	Open Hearth	Electric	
	%	%	%	kilotonnes
Canada	56.4	16.6	26.9	14,387
U.S.A.	60.6	11.1	28.3	109,614
EEC	74.9	1.4	23.5	125,385
Japan	75.2	-	24.8	101,694

NOTE: Does not add up to 100% due to rounding errors and limited use of direct reduction processes (see Section .3).

SOURCES: /19/; Statistics Canada: Catalogue 41-001, December 1982.

[1] Tuyere injection of hydrocarbon fuels and better sizing of coke are improving efficiencies./12/

percent of steel production for various countries. It is estimated that by 1990 electric furnaces will account for 30 percent of total world steel production or double the tonnage in 1980./13/

Electric Furnaces

These furnaces can be used to produce all types and grades of steel. Electric current is used to melt steel scrap and iron ore. During the process a slag forms over the molten metal. This slag protects the steel from the environment and is also used to diffuse needed alloying elements into the steel. Coke is added as a carbon source and/or to provide a reducing agent. The slag layer, which is only several inches thick can have up to a 30 percent coke content./12/ This could be either petroleum or coal coke and may include charcoal or woodchips. The composition varies depending on the desired end product and the type of steels used as scrap. The end product can also impose stringent requirements on the coke i.e. low sulphur and ash content for stainless steels.

Basic Oxygen and Open Hearth Furnaces

The heat for melting the iron ore and steel scrap is provided by consuming high BTU fuels and oxygen. There was no evidence in the literature that coke is used in these furnaces.

.3 Direct Reduction Furnaces

Certain areas do not have suitable coals and iron ores for blast furnaces. This has led to the development of the direct reduction process. Direct reduction furnaces are used to:

- produce steel directly from iron ore;
- make sponge iron which is equivalent to blast furnace pig iron;
- and produce low carbon iron for use as melting stock.

There are many different direct reduction processes using either solid or gaseous reducing agents./12/ The number of direct reduction plants in operation or under construction in 1979 are shown in Table 2-9.

TABLE 2-9

Direct Reduction capacity in operation, under construction, or planned in 1979

Country	# of plants	Total Capacity kilotonnes per year
North America	12	3,365
Latin America	7	3,600
Europe	10	2,311
USSR	2	5,000
Africa	5	2,900
Middle East	6	5,215
Oceania	1	125
Asia	15	4,314
Total	58	26,830

SOURCE: /6/.

The growth of direct reduction has averaged just over 15 percent per annum from 1950 to 1980. The capacity increments are tabulated below.

	Capacity in kilotonnes				
	1950-60	1961-70	1970-75	1976-80	1981+
Capacity Addition[1]	200	1,500	3,400	10,000	8,600
Total Capacity	200	1,700	5,100	15,100	23,700

[1] Excludes over 3 million tonnes capacity in Iran as start up dates unavailable.

SOURCE: /6/.

Future projections see demand for direct reduction iron reaching over 90 million tonnes by 1990./4/ Present consumption is limited by the higher prices demanded for direct reduction iron. Most direct reduction processes use natural gas as the fuel. It is felt that technological developments allowing the use of cheaper reducing agents will lower the relative price between direct reduction iron and scrap metal, thus stimulating demand.

.4 Cupola Furnaces

These furnaces are used primarily in the manufacture of cast iron products. Although they can be used to manufacture cast steels, the use of cupolas in this area has been largely supplanted by electric and open hearth furnaces.

The cupola resembles a miniature blast furnace, the major difference is that pig iron and steel scrap replace iron ore as the feedstock materials. A special grade of coke, commonly known as foundry coke, is used in the cupola. The ratio of coke to metallic charge varies, but appears to range from 5 to 10 percent of the weight of the metallic charge./12/

.5 Iron Sinter and Iron Pellets

These processes are used to upgrade iron ore fines, flue dust, low grade ore concentrates and other iron bearing materials into a form that is suited for use in the blast furnace.

The fire ores or other iron bearing material is well mixed with a finely divided fuel such as coke breeze or coal. This mixture is passed through a furnace to form porous, coherent lumps that are well suited to blast furnace operation.

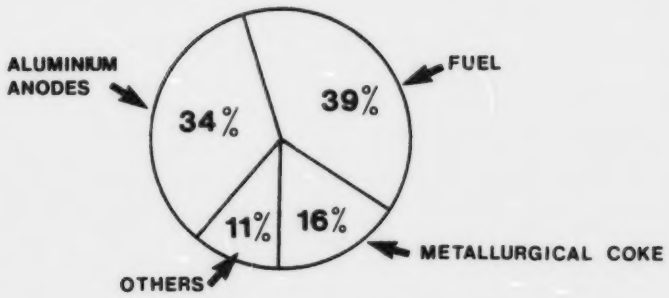
232 PETROLEUM COKE USES

Petroleum coke is essentially a by-product with supply being highly inelastic with respect to its price. Figure 2-3 shows the estimated 1980 U.S. petroleum coke markets. As the United States accounts for approximately 80 per cent of world production this distribution is assumed to represent global consumption.

As can be seen in Figure 2-3, Aluminum anodes represent approximately 34 per cent of petroleum coke production. A total of 4 million metric tonnes is exported for this use. The demand for this coke is directly linked to the health of the aluminum industry. The world's primary aluminum industry has recently been going through a severe downturn, with many of the higher-cost producers shutting down. Thus, some of the high grade petroleum coke is being displaced into the lower value markets such as metallurgical coke and fuels./1/ These markets are summarized in Table 2-10.

FIGURE 2-3

Petroleum Coke Markets



SOURCE: Figures based on U.S. market data as reported in /1/.

TABLE 2-10

Petroleum Coke Quality Requirements

Market	End Use	Quality Required
Calcining	Aluminium & Steel Anodes	Sulphur <3% or better low metal content, i.e. - Vanadium <200-250 p.p.m. - Silicon <200-300 p.p.m.
Metallurgical	Steel electric furnaces & mix with coal coke for blast furnaces	Sulphur <4% (depends on coal mixture, low sulphur coals can tolerate higher sulphur levels)
Fuel	Utility, Cement	Sulphur content limited by local emissions restrictions

SOURCE: /1/.

233 OTHER USES

The non-steel use of coke can be summarized as:

- processes requiring coke to supply carbon for reduction. In these processes the coke supplies reducing agents and/or heat.
- processes using coke as a carbon source. The carbon is generally graphitized by further heat treatment.

.1 Reduction Processes

The reduction of various ores is tabulated below. The quantity of coke per ton of end product would represent an average amount used. The cokes can be either coal cokes, petroleum cokes, coke breeze, coal or a mixture of all of these.

Raw Material	End Product and Process	Coke Consumption
		Qty Coke/Qty Product
Bauxite	Production of Aluminium Chloride	300 lbs/tonne
Calcium phosphate	Electric furnace to produce elemental phosphorus	1.3-1.5
Phosphates	Electric furnace production of 85% phosphoric acid	0.34-0.45
Phosphates	Blast furnace production of 100% phosphoric acid	3.5
Calcium oxide	Electric furnace production of Calcium carbide	0.65-0.70
Calcium carbide & nitrogen gas	Calcium cyanamide in electric furnace	0.65
Silica	Silicon carbide in electric furnace	1.4
Bauxite	Fused alumina	200 lbs/tonne
Ilmenite and Titaniferous Ores	Titanium dioxide in electric furnace	0.25-0.30

SOURCE: /17/.

.2 Other Processes Using Coke

Cokes are used, depending on their physical properties in the following areas:

Processes	Coke Consumption
	Coke Qty/Qty Product
Activated carbon manufacture	See section 3
Manufacture of electric furnace graphite	1.1
Manufacture of aluminum electrodes	See section 2

SOURCE: /17/.

2.4 SUMMARY

The importing coal coke nations, which include Austria, Brazil, Denmark, Finland, Luxemburg, Norway, Spain, Sweden and Switzerland imported 7 million tonnes in 1980, consuming almost 5% of the world's coal coke. Imports for this group increased at an average annual rate of almost 3% from 1976 to 1980.

Exporting nations, which include the United Kingdom, West Germany, F.R.G., Italy and Japan, supplied almost 11.5 million tonnes of coal coke in 1980.

The U.S.A. produces approximately 80% of the World's petroleum coke, exporting almost 70% of its production. The major market for petroleum coke is the aluminum industry.

Both coal cokes and petroleum cokes are expected to have increased sulphur content in the future. This will limit supply in those markets that require low sulphur content.

The steel industry's blast furnaces consume most of the world's coal coke. Recent cutbacks in raw steel production are resulting in a reduced demand for cokes. Uses of cokes in electric furnaces and direct reduction furnaces are expected to increase in the future as these processes become more prevalent.

Cokes are used in electric furnaces in the chemical and ore refining industries. Petroleum cokes compete with coal cokes for use in these furnaces. Supplies of petroleum cokes available for metallurgical use will depend upon the level of activity in the aluminum industry.

PART 3

PRODUCTION AND CONSUMPTION OF ACTIVATED CARBON

3.1 INTRODUCTION

The global production of activated carbons and current conditions in the activated carbon industry are presented below.

Feedstocks for manufacturing activated carbons and the production of activated carbons from peat is examined. The final section describes the uses of activated carbons in industry.

3.2 GLOBAL PRODUCTION

Estimates of the production of activated carbon are shown in Table 3-1. Literature sources show wide variations in production estimates. The small number of large producers (the six largest have capacity equal to world production) results in a high degree of confidentiality. Therefore, the data represents Monenco's best estimate based on an evaluation and reconciliation of available sources.

TABLE 3-1

Estimated Activated Carbon Production

Quantity in kilotonnes

Year	U.S.A.	W. Europe	Japan	World
1978	105	75	50	250
1979	105	75	55	255
1980	95	77	57	255
1981	92	80	55	250

SOURCES: /1/2/3/6/.

European activated carbon production is centered in the Netherlands, W. Germany, France and the United Kingdom. The largest producer is Norit N.V., headquartered in the Netherlands, which claims to produce twenty percent of the world's consumption of activated carbon./3/ The Norit plant in the Netherlands uses peat as a raw material while the plant in Scotland has used peat but presently is using wood as a feedstock. Bayer, the German manufacturer, originally used peat coke produced at Elisabethfehn, but has since converted to a brown coal feedstock.

The largest American manufacturers, ICI America, Calgon, and Westvaco each have production capacities exceeding 45,000 tonnes per year. The primary feedstock appears to be coal, with no identified manufacturer using peat.

According to various industry sources, most manufacturers are producing at 60-70 percent of capacity. Current overcapacity in the industry appears to have resulted from two factors. First, the anticipated growth in the use of activated carbons to treat water supplies has not materialized. The cost of these installations has resulted in powerful lobby groups, especially in the U.S.A., which are opposed to legislated use of activated carbons./5/ Given the lack of information on the cost/benefits of removing trace pollutants, these issues cannot be resolved until further research is completed. Secondly, the worldwide recession has slowed growth in traditional areas of application.

The industry is considered mature with producers manufacturing many different grades adapted to specific requirements of end users. The large manufacturers offer intensive product support, including: laboratory pre-testing to select the activated carbons; leasing of specialized units to control accidental spills of toxic contaminants; and turnkey design and installation of large activated carbon applications.

321 FEEDSTOCK FOR ACTIVATED CARBONS

Activated carbons can be made from any carbonaceous material, including blood, flesh and bones of animals, plant materials, peat, coals, tars, pitches, petroleum and carbon black./4/

TABLE 3-2

Sources for Activated Carbons in 1978

Raw Material	% Used N. America	W. Europe
Coal family including: peat, lignite, bituminous coal and anthracite.	72	66
Wood Charcoal	19	7
Coconut Shell Charcoal	3	11
Sawdust	4	16
Petroleum Coke	2	—

SOURCE: /2/.

Selection of feedstocks is based on the price and availability of the material, processing costs and the end uses. The volatile content of the raw material affects processing costs (The lower the volatile content the higher the resulting yield)./2/ This accounts for the popularity of bituminous and anthracite coals in the U.S.A. and Europe (Raw peat volatile content is roughly 60-70 percent versus 2-30 percent for coals).

Although all grades of activated carbons can be made from peat, the type of contaminant to be adsorbed, configuration of the process and required speed of adsorption imposes constraints on the feedstock material./4/ Generally coal and coconut shells are used for gas adsorption carbons. However, the technique used to process the raw material has a greater impact on the adsorptive powers of the finished product than the material source./7/ Other considerations, such as abrasion resistance and strength influence feedstock selection.

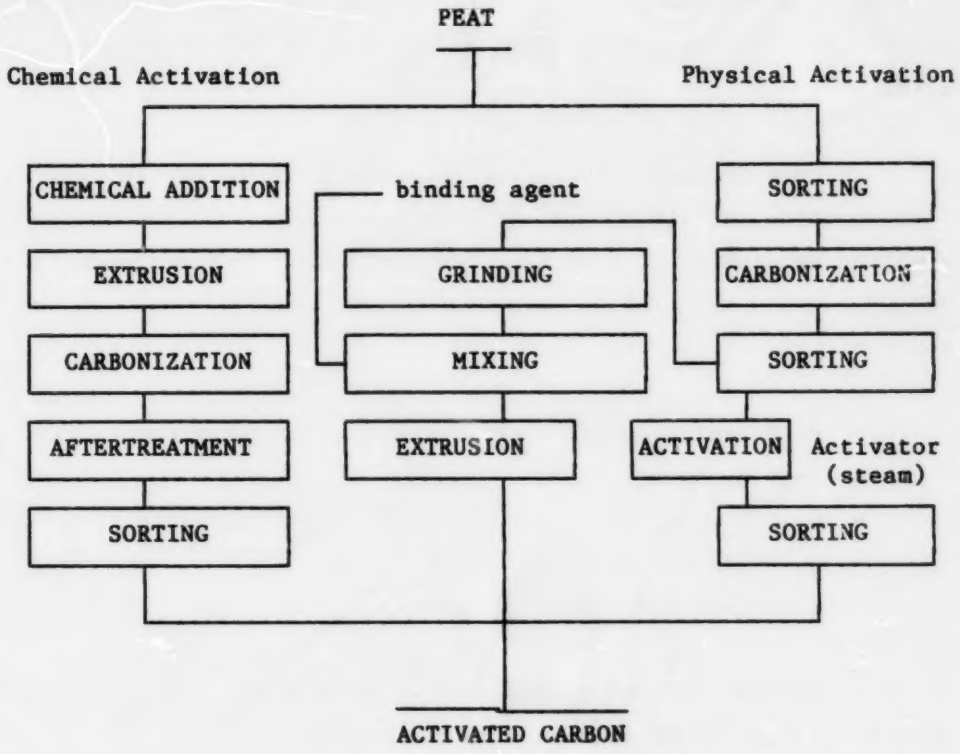
3.3 PRODUCTION OF PEAT ACTIVATED CARBONS

Activated Carbon can be produced from peat via processes outlined in Figure 3-1. In the chemical activation method, either zinc chloride or phosphoric acid is added to peat, the mass is extruded, carbonized and possibly gasified gently with steam, and scrubbed. In the physical activation, peat is first coked and then activated with steam. If the aim is to manufacture carbon suitable for gas phase applications, the micropore structure should be very developed. On the other hand, the macropore volume should be developed for water phase applications. VTT has determined that the variables presented in Table 3-3 affect the production of activated carbon.

The quality of peat has an effect primarily on the chemical composition and on the basic pore structure. If the peat contains high proportions of detrimental substances, primarily ash and iron, it is unsuitable as the raw material of activated carbon. The ash content of the product should usually be less than 15%. The product should not contain soluble components or iron if it is used in food stuff or the medical industry. In experiments carried out with Finnish raised bog peat, VTT found that when the ash content of

FIGURE 3-1

Alternative Processes to Produce Activated Carbon from Peat



activated carbon is about 11%, about 4% of ash is water-soluble and 24% soluble in hydrochloric acid. About 80% of ash can be washed off with fluorhydric acid. VTT found that the ash content of Norit peat activated carbons was 6%. About 6% of this was water-soluble, about 50% soluble in weak hydrochloric acid and about 60% in fluorhydric acid.

Only mechanically strong sods can be used both for coking and for producing activated carbon. This imposes constraints on the handling and coking of peat (see Section 7.2). The most significant variables in activation are temperature and residence time in the reactor.

Different oven types can be used for activation:

- drum ovens,
- shaft ovens,
- multiple-hearth ovens, and
- fluidized bed ovens.

In certain oven types, such as drum ovens, the activation can be carried out in the same unit as the coking.

The multiple-hearth oven can be used for producing activated carbon, and it is the most generally used process in the production of activated carbon from coal. Fluidized bed ovens are used for regenerating activated carbon, but are not often used for producing activated carbon.

Information on the production costs of peat-derived activated carbon was not available. According to VTT estimates, the minimum size of a Finnish production plant would be 1000-1500 t/a, when peat coke is used as the raw material.

TABLE 3-3

Variables Affecting the Production of Activated Carbon

Condition	Variable
Quality of peat	Plant species composition. Degree of decomposition. Chemical composition. Particle size distribution of the peat mass in the peatland.
Handling of raw peat	Moulding degree, moisture and device. Sod peat machine and sod peat size. Field drying conditions. Final moisture in field drying. Strength and homogeneity of peat sods. Conditions of artificial drying at the final stage. Final moisture content and the rate of temperature rise in the drier.
Carbonization conditions	Rate of temperature rise. Final temperature in carbonization. Gas atmosphere in carbonization. Carbonization equipment, method of heat transfer.
Activating conditions	Temperature. Gas atmosphere in activation. Activation time. Degree of activation. Activation equipment (reactor principle and equipment).

3.4 USES OF ACTIVATED CARBONS

The use of activated carbons is generally considered when there is a need to remove small quantities of contaminants from large volumes of liquids or gases./4/ Consequently, they are used in a variety of industries.

Activated carbons are classified as to whether the adsorbent is in the liquid or gas phase and whether or not the activated carbon is used as a catalyst. See Table 3-4 for a summary of carbon use.

TABLE 3-4

Estimated Use of Activated Carbons in 1982

Type	Application	% Usage
Water-phase adsorbent	- Potable water	36
	- Effluent, sewage and decolorising	36
Gas-phase adsorbent	- Air purification	14
	- Solvent recovery	9
Catalytic	- Special chemical reactions	5

SOURCE: /2/.

341 WATER-PHASE ADSORBENTS

Approximately 60 percent of activated carbon is used in the powdered form./4/ The powder is mixed with the liquid, allowed to settle and then removed by filtration. After use, the spent powdered carbon is generally disposed of. The use of powdered carbons is

declining because granular carbons offer advantages in handling as they can be re-activated, thus reducing overall costs./2/

Granular carbons are used in filters, through which a liquid is continuously percolated. When spent, the granular carbon is reactivated either by the original supplier or on site by large users.

There are many large scale applications of water-phase adsorbents, i.e., Effluent treatment, sugar processing, removal of oil from refinery wastewater, and de-chlorination of water used in the production of beverages. A listing of applications is summarized below:

Process	Comments
- Sugar refining	- Removal of small quantities of colour matter
- Effluent and waste water treatment	- Removal of organic matter - Removal of tastes and odor
- Insecticide manufacturers & electroplating industry	- Removal of toxins or other harmful contaminants
- Laundry & vehicle washing	- Removal of detergents
- Oil refineries	- Removal of oil from wastewater
- Beverage industry breweries, wineries & soft drinks	- Removal of chlorine - Removal of contaminants
- Pharmaceuticals	- Removal of impurities - Preparation of chemicals
- Mineral recovery	- Trace elements captured by active carbons

SOURCE: /4/.

342 GAS PHASE ADSORBENTS

Gas treatment carbons are typically made in larger particle sizes of greater strength and density than liquid treatment carbons. There are applications where special pelletized activated carbons are required i.e., large volume air flow through a bed that can tolerate a low pressure drop. These are formed by mixing crushed carbon with a binder and then extruding the mixture through a form or mold. They are typically supplied as cylinders with diameters ranging from 1mm to 10mm and lengths from 2mm to 25mm./2/

The use of solvent recovery-grade activated carbon for the recovery of volatile organic compounds from process air streams is important to the operating economics of several industries i.e., dry cleaning and tape manufacturing./4/

The users of gas-phase adsorbent carbons are extensive, therefore the following list only includes the more common applications.

Process	Comments
1) Vapour Adsorption	
- gasoline vapor emission control	- fuel depots & automobiles
- paint recovery	- spray baths
- nuclear industry	- recover radioactive contaminants
2) Solvent Recovery	
- dry cleaning	- reclaim contaminated solvent
- sound & video tape manufacturers	- reclaim solvents
- rotogravure printing	- reclaim solvent and eliminate dye contamination

3) Odor Removal	
- sewage treatment plants	
- foundries	
- air conditioners	- hospitals, auditoriums and large buildings
4) Air Filters	
- gas mask	- chemical warfare
- cigarettes	- removes tars & nicotine
- kitchen range hoods	- traps grease & odors

SOURCE: /4/.

343 CATALYTIC GRADE ACTIVE CARBONS

There are two broad groups in this category. The first are the use of activated carbons as catalyst carriers. The second are the use of special impregnated carbons that act as catalysts. Following is a list of these uses and the function of the catalyst.

Process	Comments
1) Catalyst Carriers:	
- hydrogenation	- recovery of precious metals i.e., gold
- mercury recovery	- for alkali manufacturing process
- PVC	- used for manufacturing
2) Catalyst Grades:	
- demercurisation	- precipitates contaminants
- desulphurisation	

SOURCE: /2/4/.

3.5 SUMMARY

Production of activated carbons is concentrated in the U.S.A. and Western Europe. The six largest producers have capacity equal to world production. Current production levels are estimated to be approximately 60-70 percent of capacity.

Activated carbons can be made from any carbonaceous material. Peat is currently used by one non-communist country manufacturer, Norit. The high volatile content of peat coke increases processing costs when compared to coal feedstock because of longer residence times required.

The production of peat activated carbon is very dependent on the quality of peat, handling of raw peat, carbonization conditions and activating conditions. The ash content of peat should be below 15 percent.

Activated carbons are used when there is a need to remove small concentrations of contaminants from large volumes of liquid or gas.

There are many large scale applications of water phase adsorbents. Gas phase adsorbents are important for certain industries, i.e., dry cleaning and tape manufacturing. Special catalytic grades are also used.

PART 4

PRODUCTION AND CONSUMPTION OF CARBON BLACK

4.1 INTRODUCTION

This section examines the global production of carbon black, uses of carbon black, the existing manufacturing methods, and current feedstocks. The relevant factors behind current consumption patterns are also highlighted.

4.2 GLOBAL PRODUCTION STATISTICS

As can be seen in Table 4-1, North America accounts for just over 44 percent of the non-communist country production of carbon black. The western countries, with well developed economies, can anticipate little growth in the production of carbon black. This reflects the mature state of this industry in these countries. However, in the developing countries, much higher growth rates prevail. For example, the only carbon black manufacturer in Africa in 1980 was situated in South Africa. Two plants, one in Algeria and one in Nigeria were scheduled to come on stream in 1983./4/ These additions reflect the rapid industrialization taking place in selected areas of the globe.

TABLE 4-1

Carbon Black Capacity

Country Group	Quantity kilotonnes/year 1980[2] Production	1980[1] Capacity	Projection 1983[1]	% Growth
North America	1339	2094	2147	2.5
Central and South America	n/a	328	381	16.2
West Europe	1140[3]	1287	1324	2.9
Africa	n/a	55	105	90.9
Japan	538[3]	550	580	5.5
Asia, Oceania & Middle East	n/a	440	588	33.6
Total		4754	5125	7.8

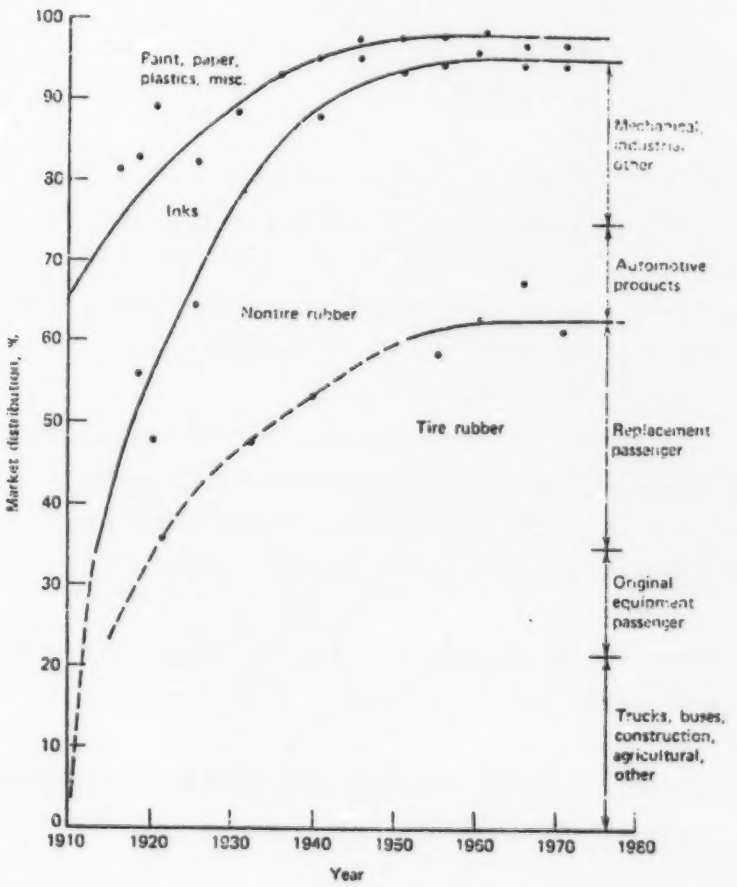
n/a: not available.
SOURCES: 1. Source /1/.
2. Source /2/.
3. Japan & France (included in West Europe) Data is for 1979.

421 CARBON BLACK DEMAND

Demand and growth in demand for carbon black in the United States shows a typical pattern that is being followed by other areas. The United States carbon black market distribution is illustrated in Figure 4-1. As can be seen, the rubber tire and rubber products consume approximately 95 percent of carbon black produced.

FIGURE 4-1

United States Carbon Black Market Distribution



Source /3/

Consumption levels are directly affected by production rates in the automobile industry, which consumes approximately 65 per cent of carbon black production. Developments in the automobile and tire industry which will tend to reduce demand for rubber and hence carbon black are /1/:

- a shift toward smaller, lighter, fuel efficient automobiles with reduced tire wear rates;

- higher relative gasoline prices reducing annual mileage;

- improved tire technology that increases wear life;

- all season tires that eliminate the need for separate summer/winter tires.

In 1980 North American production was only 64 per cent of capacity, although production in Canada was at capacity. Production dropped nearly 17 per cent between 1979 and 1980 in North America according to OECD data. The recession in the automobile industry between 1980 and 1982 weakened demand further.

Consumption in non-rubber uses, which includes inks, paints, plastics, paper and other miscellaneous areas accounts for the remaining 5 per cent of carbon black uses. These carbon blacks tend to be specialty products and thus command higher prices. They are used in:

- Inks, for which special grades of carbon blacks have been developed.

- Paints, lacquers, enamels, and industrial finishes use a wide range of carbon blacks.

- Plastics - special polyethelene compounds containing up to 50% carbon black have been developed. Carbon black content can improve weather resistance for cable jackets.

- Paper - including black papers for album covers, leatherboard, wrapping & bag papers, highly conductive & electrosensitive paper, and a black tape for wrapping high voltage transmission cables.

- Miscellaneous uses including high temperature insulation (up to 3000°C); carbon brushes and electrodes; and dry cell batteries.

422 FEEDSTOCKS

Today's carbon black production is almost entirely by the oil furnace black process. This demands aromatic hydrocarbon feedstock, that is free of gritty materials and contains low levels of asphaltenes, sulphur and alkali metals./3/

In North America the most important feedstocks are the heavy residual decant oils left from gasoline production. Another important feedstock is the steam pyrolysis residual tars from the manufacture of ethylene. There has been very limited use of coal tars, napthalene, and anthracene oils from coal tars because of limited quantities and high prices.

A small percentage of carbon black is produced by the older thermal black process. These use natural gas for feedstock. There are three world producers still using this process, with one located in Alberta./1/

4.3 SUMMARY

The carbon black industry is considered mature, with growth being experienced only in rapidly developing countries.

Ninety-five percent of carbon black is consumed in the rubber industry, with 65 percent being consumed by the automobile industry. Developments in the automobile and tire industries show a reduced demand for carbon blacks.

There has been very limited use of coal tars for the production of carbon black due to their high price and low availability. The most important current feedstocks are the heavy decant oils from gasoline production and residual tars from the manufacture of ethylene. The possible aliphatic nature of peat tars (see Section 6.2.2) would eliminate their use as a feedstock in carbon black production.

PART 5

PRODUCTION AND CONSUMPTION OF WAXES

5.1 INTRODUCTION

The properties and characteristics of peat wax and the uses of competing waxes are described in this section.

5.2 PEAT WAXES

A recent article concluded: "Peat wax thus contains valuable long-chain lipid components and has many good physical properties. It could be used like montan and carnauba waxes in many applications.... However, the peat extracts also contain considerable amounts of unknown non-lipid substances, which still remain to be identified. Only when the compositions and characteristics of the extracts are known, can the area of utilization of extract products be extended and developed."/3/

There was no information on specialized uses of peat waxes, or any evidence that they are being produced commercially. The literature survey indicated that there are presently no economically viable processes for the production of these waxes. Another article concluded: "The cost calculations indicate that the manufacture of peat wax from dried sod peat or milled peat is not profitable at this stage....Since the properties of peat wax resemble those of montan wax, it is apparently difficult to find new peat wax uses, from which the cheaper montan wax would not also benefit...."/4/

The physical properties of peat and montan waxes are compared in Table 5-1. Peat waxes are dark brown almost black in colour, hard and brittle. They have lower melting points than montan waxes and higher oxygen content.

TABLE 5-1

Characteristics of Peat and Montan Waxes

Characteristics	Finnish Peat	English Peat	Scottish Peat	German Montan
Melting Point °C	70-78	63-68	64-73	74-82
Acid number, mg KOH/g	38-50	50	48	33
Saponification no. mg KOH/g	87-120	119	113	76
Ester number mg KOH/g	---	69	65	43
Specific gravity g/cm^3	1.01	1.03	---	1.05

SOURCE: /4/.

521 MONTAN AND CARNAUBA WAXES

Montan waxes originate in two locations, Eastern Germany and California, U.S.A. The wax is obtained by solvent-extraction of lignite or brown coal. Because of its origin, montan wax is classified as a mineral wax, however chemically, it is more closely related to the hard vegetable waxes like carnauba.

Carnauba wax is exuded from the leaves of the Northern Brazilian carnauba palm. The wax is obtained by beating the dried palm leaves. Carnauba wax is a yellowish-green color, very hard, tough and lustrous. On warming, it has a characteristic odor of new-mown hay. It is the hardest of the natural waxes and commands the highest prices.

Montan wax is used as an inexpensive substitute for carnauba wax when color is unimportant. It has a bituminous odor on friction or warming. Crude Montan wax is brownish-black and quite hard. It is considered to be the most important wax used in European industry.

These waxes are used in:

- candles;
- wood polishes;
- cosmetics;
- polishes for leather and linoleum;
- in metal working for precision castings;
- protective coatings;
- medicinals for salves and ointments.

522 SYNTHETIC WAXES

Synthetic waxes are increasing in use and appear to have displaced the natural waxes in many applications, especially floor polishes. These waxes can be formulated to give a variety of properties. As a result of the cheaper feedstock materials they can offer significant price reductions to the consumer when compared to natural waxes. In the case of floor polishes, they also result in a superior product that requires less labour to apply.

523 PARAFFIN WAXES

Paraffin waxes appear in many different grades with varying physical properties. They are found in many kinds of crude petroleum and are extracted from the high boiling fractions during the refining process. The largest percentage of paraffin wax on the market is refined type. Typical properties of these waxes are: they contain a small percentage of oil; are hard; and have been refined to the point where they are tasteless, odorless and stable to light.

Uses include: candles; waterproofing; sealing; lubricating; protection of foods, plants, fruits and vegetables; paper; polishes; cosmetics; crayons; pharmaceutical ointments and salves; electrical insulation, etc.

5.3 SUMMARY

Peat wax is compared in the literature to montan and carnauba waxes. These two waxes are produced in Germany, California and Brazil.

Many components of peat waxes still have to be identified. Unless unique properties of peat waxes are identified for specific applications, they will not be able to compete with the lower priced Montan waxes.

PART 6

PRODUCTION AND CONSUMPTION OF TARS

6.1 INTRODUCTION

This section outlines the global production statistics of tars. The uses of both coal tars and peat tars are examined.

6.2 GLOBAL PRODUCTION STATISTICS

An aggregated grouping for the production of coal tar, lignite tar, peat tar and water gas, is summarized in Table 6-1. Tar production has been decreasing since 1977, falling an average of 5.7% per year in North American and 1.1% in Europe from 1977 to 1981.

TABLE 6-1

Production of Tars Obtained from Coal, Lignite, Peat & Water Gas

Producing Areas	Quantity kilotonnes		
	1977	1979	1981
North America	2729	2451	2159
Western Europe	3408	3264	3256
Oceania	233	233	233
Total	6370	5948	5648

SOURCE: /1/.

6.3 USES OF TARS

631 COAL TARS

The uses for coal tars are well documented, indicating that these tars are important for the chemical and aluminum industries. For a detailed listing of the constituents and their uses see Table 6-2.

The light oils (boiling points to 250°C) can also be processed into motor gasolines or aviation fuels as well as the chemical feedstocks noted in Table 6-2.

The middle oils (boiling points between 250°C to 450°C) can be processed into diesel fuels or kerosene as well as the creosote chemical feedstock noted in Table 6-2.

632 PEAT TARS

There is little information available on the properties of peat tars. Information available to Monenco about the use of Peat tars in Russia is summarized in Table 6-3.

Another reference to peat tars described them as: "peat tars are multi-material mixtures which, in contrast to coal tars, are aliphatic in nature."/5/ This would indicate that peat tars are similar to heavy petroleum residues that have low aromatic constituents. However, the use of peat tars to produce creosote in Russia, implies that aromatic components can be isolated.

TABLE 6-2

Coal Chemicals

Coal Chemicals Recovered	Uses
Ammonium Sulphate	mixed with phosphate & potash to provide fertilizers.
Phenol (C_6H_5OH)	- manufacture of resinous condensate - e.g. 'Bakelite' - used as a chemical intermediate in the preparation of: - synthetic tanning dye intermediates, perfumes, plasticizers, refining and lubricating oils.
Ortho Cresol ($CH_3C_6H_4OH$)	- production of synthetic resins - insecticides & weed killers - artificial flavours & perfumes
Meta-para Cresol	- synthetic resins - plasticizers - insecticides, dyestuffs, pharmaceuticals & photographic compounds
Napthalene	Converted to pthalic anhydride - plasticizers - coatings, resins, dyes, agricultural chemicals, pharmaceuticals, insect repellents.
Pyridine Bases	- solvents - waterproofing - pharmaceuticals
Pitch	- binders for anode manufacture
Light Oil	- plastics, solvents - resins, synthetic detergents - rubbers, nylon - organic chemicals i.e. DDT, Nitro-benzene etc.
Heavy Solvent	Rubber compounding floor tiles, printing inks, laquers & chewing gum, ship bottom paints, pipe coatings wire enamel, shoe polish, interior paints.

SOURCES: /2/3/4/.

TABLE 6-3

Peat Tars, Constituents and Uses in Russia

Peat Tar Components	%	Uses
waxes	4-8	waxes, ointments
paraffins	4-8	waxes, ointments
phenols	12-18	chemicals & plastic feedstock
nitrogen bearing bases	1-3	
neutral oils	40-60	liquid fuels, creosotes
asphalteens	8-15	road tars
carbides	1-2	
carbonate acids	1-3	

6.4 SUMMARY

The use of coal tars is well documented. These tars, by-products of coal coking, have many useful components which are used in a variety of industries. The chemical and aluminum industries are large users of coal tar components.

The constituents of peat tars are not well known at this time. Peat tars appear to bear a closer resemblance to petroleum than to coal tars. However usage of peat tars in Russia indicates that they have some components similar to coal tars.

PART 7

PEAT COKE PREPARATION AND CHARACTERISTICS

7.1 INTRODUCTION

The production processes leading to peat coke manufacture and their effect on peat coke characteristics are examined in this section.

The use of peat coke in the areas identified in Part 2 are analyzed. The analysis is based on a literature survey, and was used in planning the mail survey summarized in Section 11.

7.2 PEAT COKE PREPARATION

According to VTT the quality of peat coke is particularly dependent on the following factors:

- Quality of peat
  - degree of decomposition
  - chemical composition
  - plant species composition
- Treatment of raw peat
  - peat excavation method
  - degree of moulding
  - sod size
  - field drying conditions
  - final moisture content
- Coking conditions
  - thermal drying conditions
  - rate of heating
  - coking method
  - final temperature.

721 QUALITY OF PEAT

As the degree of decomposition increases, the volatile content of peat is reduced and the carbon content is increased (see Figures 7-1 and 7-2). Therefore, well decomposed peat grades should be chosen for the raw material of peat coke to guaranteee as high a coke yield as possible.

The degree of decomposition also affects the strength of peat sods. Readily crushed sods are obtained from weakly decomposed peat. The strength of sods is a function of the decomposition degree, as indicated in Figure 7-3. This figure also shows that differences in strength are greater for Sphagnum moss peat than for Carex peat[1]. Sods made from weakly decomposed peat dry poorly (due to rewetting) on the field. The high moisture content results in sods that crumble easily.

Low-grade sods also give a low-grade coke with an increase in the amount of fines.

722 TREATMENT OF RAW PEAT

The method used in moulding of peat moss is one of the most significant factors affecting the strength of sod peat. By mechanical moulding the fibrous components of peat can be broken up and mixed with the colloidal peat mass. This increases the density of sod peat improving strength./3/

The moisture content of sod peat when excavated also affects the strength. The higher the moisture content, the higher the bulk

1 Sphagnum peats are derived from sphagnum mosses. Carex peats are derived from the sedge family plants.

density and sod strength. It has been found in practice that the moisture content of peat should be greater than 85% when producing peat sods.

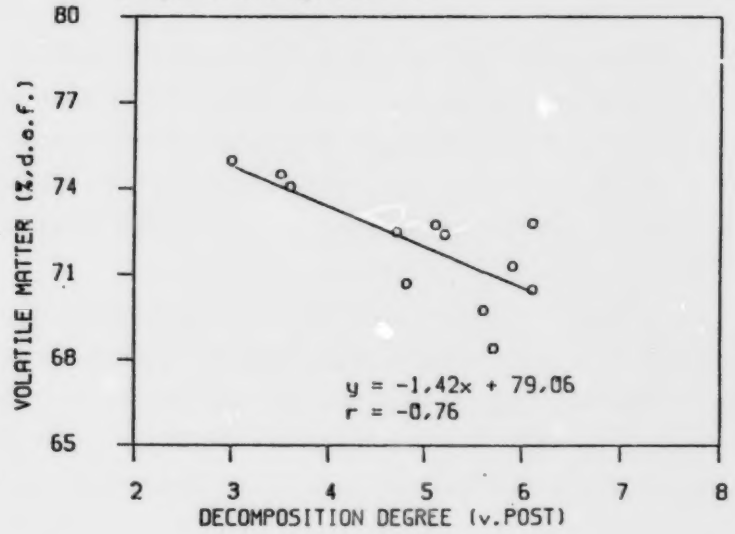
As the peat sod dries, a significant shrinkage takes place, and the volume of the sod can be decreased by as much as 80%. It has been found in practice that the shrinkage proceeds linearly to a moisture content of about 30%, see Figure 7-4./3/ This moisture content can be reached in optimum field drying conditions.

It was found in a laboratory study that a definite increase in the strength to withstand peat handling begins at moisture contents below 50-55%, see Figure 7-5. It has been found in practice that it is necessary to achieve a moisture of 35-40% by field drying, if the sods are to withstand the coking stage. Generally, it can be concluded that the greater the reduction in moisture through field drying, the better are the handling characteristics of the sods. This also results in a lower energy consumption in the drying stage before coking.

The sod peat of 30-40% moisture content is dried to a moisture content of 10-20% before the actual coking. The rate of shrinkage continues non-linearly after reaching the moisture content of 30% and continues until all water has evaporated. To prevent the sod from cracking and losing its strength the drying normally proceeds slowly.

FIGURE 7-1

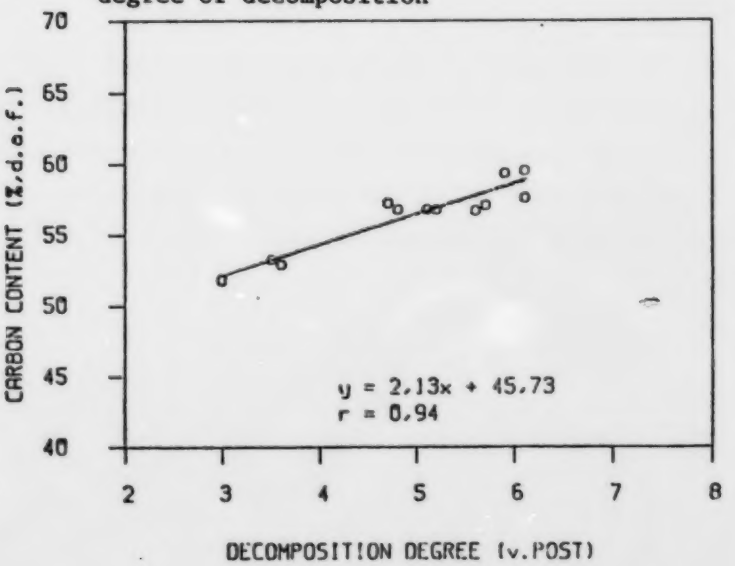
Dependence of the amount of volatiles on the degree of peat decomposition



SOURCE: /1/.

FIGURE 7-2

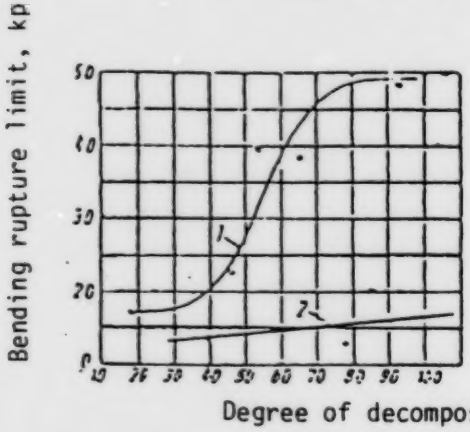
Dependence of the carbon content of raw peat on the degree of decomposition



SOURCE: /1/.

FIGURE 7-3

Dependence of the bending strength of sod peat on the degree of decomposition



1. Sphagnum moss peat
2. Carex peat

SOURCE: /2/.

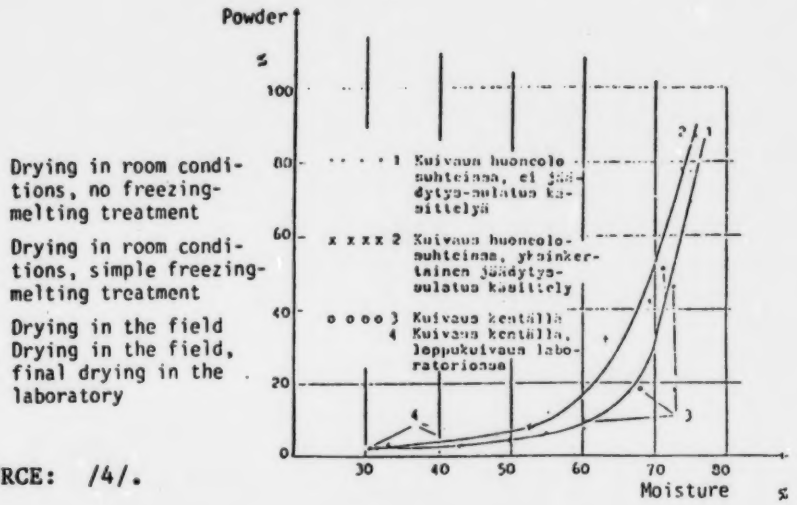
FIGURE 7-4

Shrinkage of moulded peat

SOURCE: /3/.

FIGURE 7-5

Resistance of sod peat to grinding



Drying in room conditions, no freezing-melting treatment

Drying in room conditions, simple freezing-melting treatment

Drying in the field

Drying in the field, final drying in the laboratory

SOURCE: /4/.

The production technology of sod peat has been studied extensively in Finland, for example by Vapo Oy and VTT, in the period 1975 - 1983. Various sod peat machines such as baggers, disc millers and screw disc millers, have been tested. It is only during the last few years that machines have been developed to produce sod peat especially suited for coke manufacture: the so-called small sod peat. The small sods dry faster and to a lower moisture content than the conventional peat sods. Thus the strength of the sods is improved, the energy demand is reduced and the time of thermal drying during processing is shortened. The quality of sod peat for coke manufacture should be superior to that used for combustion. The sod peat standard of the Association of Finnish Peat Industries is presented in Table 7-1.

TABLE 7-1

Characteristics of Finnish Sod Peat

Property	Standard Sod P12 /5/	Small Sod
Moisture content, %	30-45	25-40
Lower heat value, Mj/kg	12	12
MWh/m^3	1.2	1.2
Ash, monthly average, max, %	10	10
individual sample, max, %	15	15
Diameter	60-80	35-45
Amount of fines, max %	15	*

* not given

723 COKING OF PEAT

The quality of peat coke is also affected by coking conditions and methods. The peat material shrinks during coking and the shrinkage is almost directly proportional to the amount of peat volatiles.

According to VTT, the average yields from the pyrolysis of medium-decomposed peat at 800 °C are as follows:

peat coke	30-35%
peat tar	10-15%
pyrolysis gases	30-35%
tar water	15-20%.

The yields and compositions of the coking products are dependent on the peat quality, peat composition and the coking conditions. The coke yield from poorly decomposed peat may be 20-25% and from well decomposed peat more than 40%.

The material balance of the process of thermolysis is shown in Figure 7-6. The decomposition is rapid at the beginning, reaches a maximum at a certain temperature and decreases gradually to zero. The decomposition is highly dependent on the temperature and increases if the temperature rises, see Figure 7-7.

At higher coking temperatures the density and the strength increase. However, the reactivity of the coke is decreased. Hence, within limits, different kinds of carbon products can be obtained from peat by varying the peat grade and the treatment process.

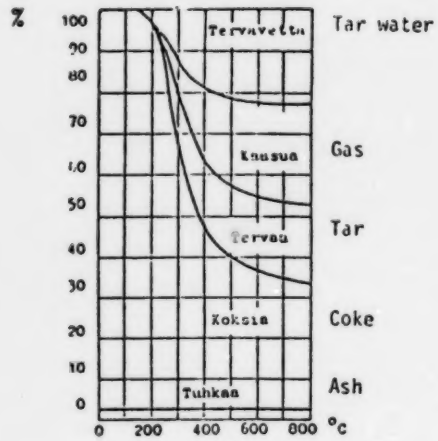
If the rate of temperature rise is high (10 °C/min) the peat sods shrink rapidly. As a consequence, the peat sods crack, the proportion of fines is increased, and the yield of solid pyrolysis products in relation to tar and gas is reduced, see Figure 7-8. However, small sod peat withstands shrinkage better than normal sod peat and therefore, the rate of temperature rise can be higher for small sod peat.

The quality of coke is also dependent on the heating rate. The following resistances to grinding have been obtained for a coke from coal: coke produced at a low rate of heating, 2648.7 J/kg; and coke produced at a high rate of heating, 1010.43 J/kg./11/

In practice, the process conditions are chosen to maximize the yield of the main product. If coke is the main product, the rate of heating is low, preferably less than 5 °C/min, so that the peat sods keep as compact as possible.

FIGURE 7-6

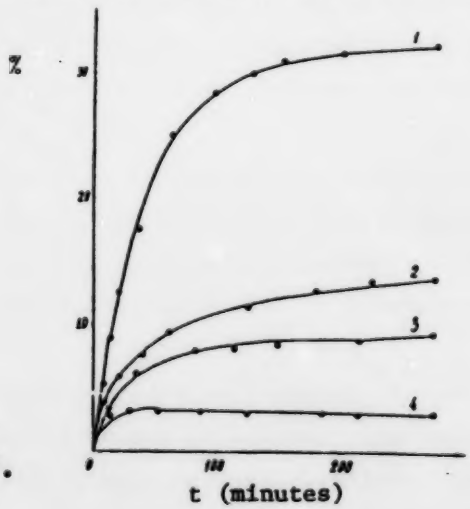
Material balance for the coking of medium-decomposed peat



SOURCE: /3/.

FIGURE 7-7

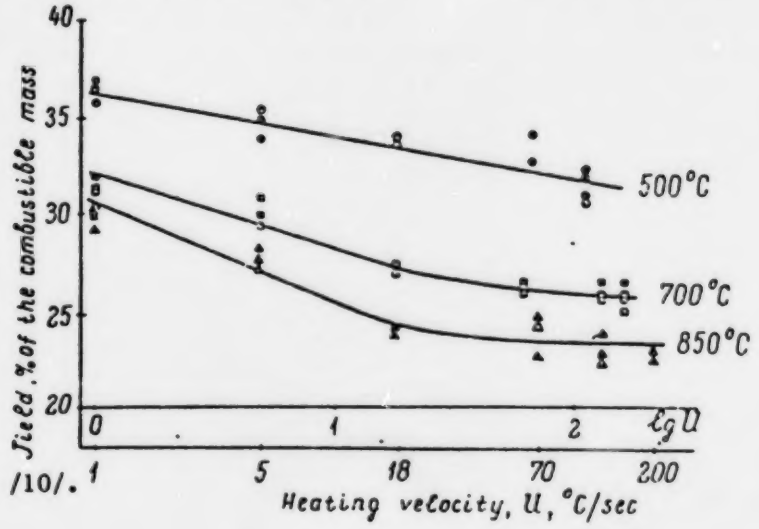
Decomposition of peat organic mass
1-250°C, 2-200°C, 3-175°C, 4-125°C



SOURCE: /9/.

FIGURE 7-8

The effect of heating rate on coke yield



Source: /10/.

7.3 PEAT COKE CHARACTERISTICS

The results obtained by of the Ontario Research Foundation in their laboratory tests on manufacturing foundry coke from peat are summarized below. For the complete report refer to Appendix B.

The peat coke samples were prepared by carbonizing a variety of peats at temperatures around 500°C. As can be seen from Table 7-2, this was insufficient to devolatize this coke and raise the fixed carbon to the levels reported by the German and Finnish manufacturers.

The method used to manufacture coke, by drying the peat, mixing with binder, and then carbonizing failed to make a strong, dense coke. Drop tests indicate that the size stability is poor, and that the coke samples degrade easily.

TABLE 7-2

Coke Specifications

Coke Samples	% Ash	% Fixed Carbon	% Volatiles	% Sulphur	Reactivity (see Note 5)
Ontario Peat Char[1]	10.8	38	51.2	0.14	Very High
Wetox Char[1]	13.8	14.8	68.7	0.01	—
German Peat Coke[2]	3-5	91	5.4[6]	0.21	Very High
Finnish Peat Coke[3]	7-11	87-91	1-3	0.1-0.2	Very High
Foundry Coke[7]	12.0[6] Max.	86.0 Min.	Max. 2.0	Max. 1.0	Low
Metallurgical Coke[4]	6.5	92/93	Max. 1.0	Max. 1.0	Not Important

NOTES:

1) Ontario Research Foundation, Report No. PP-PSEF-84-40-20227, 1984. See Appendix B.
2) Source /5/.
3) VTT report to Monenco.
4) As specified by a Canadian blast furnace operator contacted in the user survey.
5) A measurement of the ability of carbon to react to oxygen or other gases. No standard unit of measurement was used. However, source 1 and the articles referenced in sources 2 & 3 indicate that peat cokes have high reactivity compared to foundry cokes or metallurgical cokes produced from coal.
6) These values calculated from given data.
7) Source /14/.

The reactivity tests indicate very high peat coke reactivity, especially when compared to petroleum cokes and foundry cokes.

The sulphur content of peat cokes is very low, especially when compared to the specifications for foundry and metallurgical coals. Considering that low sulphur content coals are becoming depleted, this is an important peat coke characteristic.

The composition of the ash is dependent on the peat grade, on the mineral content of the adjacent mineral earth and on hydrological conditions in the peatland. The main components of ash for Finnish coke are given in Table 7-3.

During pyrolysis, the inorganic components of peat are mainly enriched in the coke, and hence the ash content of the coke is in most cases increased about three-fold compared to the raw material. Thus the ash content of raw material should be as low as possible. As the amount of inorganic components in coke does not appear to restrict the use of peat coke in many fields of metallurgy, peat grades with 3-4% ash content can usually be used as the raw material.

Most of the sulphur evolves along with volatiles in the coking. Therefore, its relative proportion in the peat coke is often the same as in the peat used as the raw material. Most of the sulphur contained in peat coke is also bound as sulphates in the ash, which reduces its detrimental effects in most applications.

Part of the peat phosphorus is usually in organic compounds, part as iron phosphate or bound in iron compounds. During the coking, apparently only phosphorus bound in organic compounds escapes and hence, the relative proportion of phosphorus is increased compared to the phosphorus content of the raw material. Although the amount is only fractions of a percent, it may exceed the requirements of certain applications in special metallurgy. Therefore, peat grades with as low a phosphorus content as possible should be chosen for the raw material of peat coke.

TABLE 7-3

Main Components of Ash

Component	Content, % Limits	Average
SiO_2	24,2-55,6	40,6
Al_2O_3	6,8-23,6	14,1
CaO	7,8-21,0	13,7
Fe_2O_3	8,6-23,0	15,0
P_2O_3	2,9- 6,0	4,1
MgO	1,7- 6,2	3,2
K_2O	0,6- 2,3	1,35
Na_2O	0,15- 0,3	0,2
TiO_2	0,3- 0,5	0,4
S	0,1- 2	1,1

SOURCE: /1/.

The iron contained in peat is often brought by groundwater and appears as iron compounds precipitated between peat layers. It has no detrimental effect in most metallurgical applications. However, if the aim is to use peat coke for the production of activated carbon for foodstuff and medicine industries a low iron content should be considered. Iron may also be a detrimental factor in the production of pure silicon.

A number of physical properties of Finnish and German peat coke grades are presented in Table 7-4.

TABLE 7-4

Physical Properties of Peat Coke

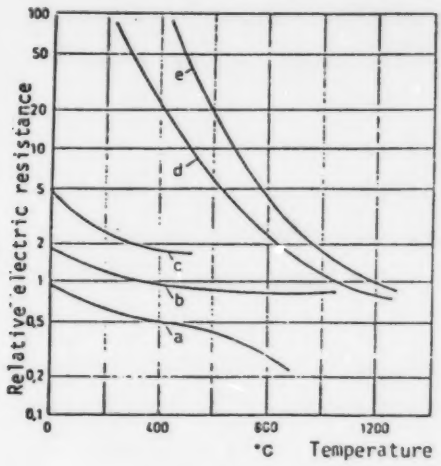
Property	Coke FIN	Coke FRG
Particle size, mm	40	200
Bulk density, kg/m^3	300-400	290-245
BET surface, m^2/g	100	220
Flash point,	230	230
Compression strength, N/m^2	400-800	400
Softening temperature of ash, °C	1280	1300
Flowing temperature of ash, °C	1380	1350
Lower heating value, MJ/kg	30-32	28-32

SOURCES: /6/, /7/.

The electric resistance of peat coke is also fairly high compared to coke grades. A dependence on temperature is also characteristic of telectric resistance of peat coke. The relative electric resistance of coke is sharply reduced as the temperature increases, see Figure 7-9.

FIGURE 7-9

Relative electric resistance of coke grades as function of temperature. Particle size 10-20mm.
a - smelting coke, b - metallurgic coke, c - gas coke, d - peat coke, e - semicoke



SOURCE: /8/.

7.4 PEAT COKE APPLICATIONS

The uses of peat coke for the various areas identified in Section 2 will be examined.

741 BLAST FURNACE COKE

Blast furnaces demand coke with hardness, defined as a resistance to fracture, and stability, defined as a resistance to abrasion./12/ When loading blast furnaces with iron ore and coke, the coke has to withstand the pressure of the iron ore and the impact of falling down through the oven.

The coke must be within specified size ranges, 20 mm to 100 mm[1]. This affects the permeability of the coke layer to the hot gases. The size also correlates with the stability and hardness of coal cokes./13/

Ash and sulphur content affect blast furnace performance. An increase in ash and sulphur content cause:/14/

- increased slag volume;
- decreased production of furnace;
- increased coke consumption per unit of output;
- and increased difficulty in blast furnace control.

These demands are summarized in Figure 7-10, which positions peat coke against coal coke. The results show that peat coke is technically not suited for this application.

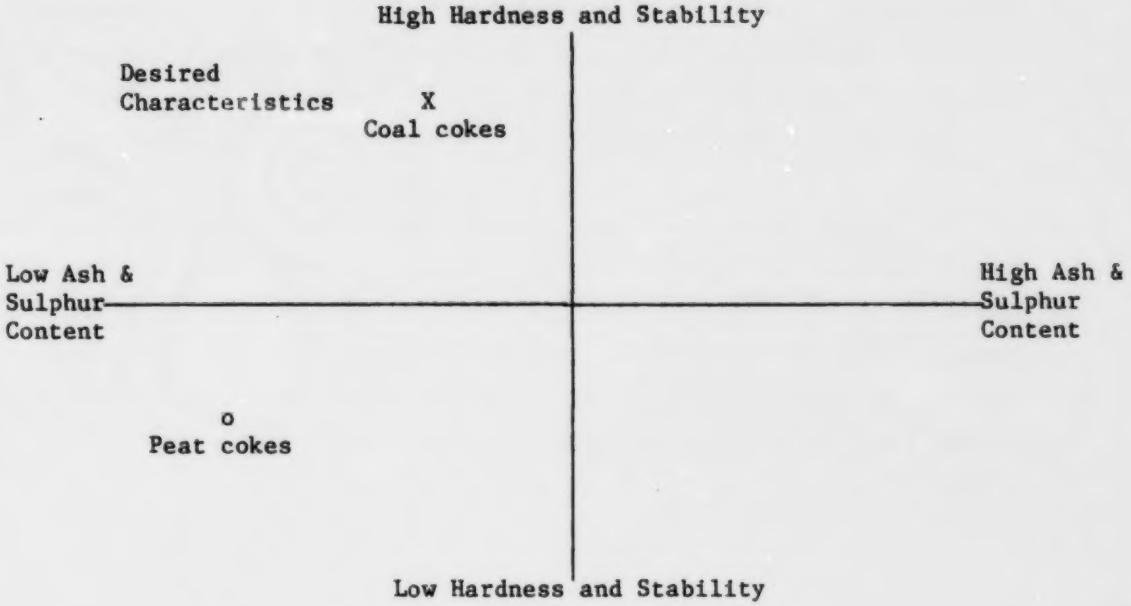
742 ELECTRIC FURNACES

The literature survey indicated no hardness and stability constraints imposed by the use of these furnaces. Depending on the raw material and end product, coke can either be used as a reducing agent and carbon raiser or only as a carbon raiser. This generally requires high fixed carbon, and depending on the material being produced low sulphur, phosphorus, and ash. High reactivity may offer processing advantages because the carbon dissolves in the solution at a faster rate.

[1] As specified by a Canadian blast furnace operator.

FIGURE 7-10

Blast Furnace Coke Requirements



As most of the steel grades and many non-ferrous products can be produced in an electric furnace, no single specification can be presented.

Peat coke is at present used mainly as a reducing agent in electric-arc furnaces in the manufacture of silicon and chrome iron. By using peat coke, together with coal coke and wood charcoal, a saving of 12-15% in electricity consumption has been achieved in the manufacture of silicon iron./8/ This is primarily due to the electric resistance of peat coke, which is sharply dependent on temperature (see Figure 7-9). The electric current flows most strongly through the lower layers, which intensifies the reduction-melting process. The total consumption of coke has also been about 20% lower.

743 DIRECT REDUCTION FURNACE COKE AND IRON ORE UPGRADING

The driving force behind the development of direct reduction furnaces is the wish to eliminate the dependance on metallurgical cokes imposed by the use of blast furnaces. The general requirements for the reducing agents are that they be easily mixed with the ore and fairly reactive./14/ The reducing agents are commonly coke breeze, charcoal and low grade coal in those furnaces not using natural gas.

There was insufficient information to determine general specifications for coke in this application, however, the use of low grade coals and charcoals indicate that peat coke should be acceptable from a technical viewpoint as they have comparable properties. The use of peat coke in iron sinter and pelletizing operations would appear technically feasible given the use of coke breeze and other coals./15/

744 FOUNDRY COKES

Cupolas can be considered as small blast furnaces whose function is to remelt iron or steel scrap. As there are no facilities for further treating of the melt, whatever sulphur and phosphorus is in the coke ends up in the end product. Consequently, there are strict requirements for low sulphur and phosphorus as these contaminants can adversely affect the physical properties of the end product./14/

Low reactivity coke is desirable in a cupola operation. Highly reactive cokes will have greater coke consumption per unit output. (See discussion, section 5, Appendix B.)

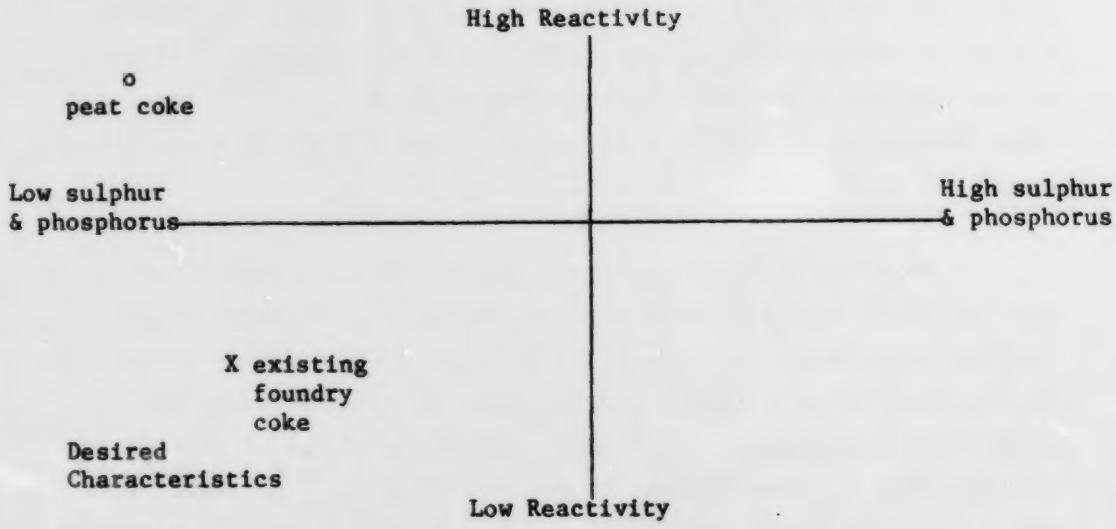
Size appears to be an important parameter. It is generally agreed that pieces under 3 inches are undesirable. The large sizes are required for:

- diminished reactivity as large pieces have smaller surface area than an equivalent volume of smaller pieces;
- and permeability of the coke bed to allow penetration by the hot gases.

A general rule of thumb appears to indicate that coke size should be approximately 1/12 to 1/10 the cupola diameter. See figure 7.11 for cupola feedstock requirements. As can be seen, peat coke could be too reactive for this application, even though the low sulphur content is desirable.

FIGURE 7-11

Cupola Coke Requirements



The Ontario Research Foundation has indicated that a simple cupola modification, the addition of extra tuyeres, may make the use of highly reactive cokes acceptable, at least from a technical viewpoint.

7.5 SUMMARY

Well decomposed peat should be chosen for the raw material of peat coke. This increases carbon content, increases coke yield and increases sod strength. Sod strength is also sensitive to peat moulding and the moisture content of excavated sod peat. Field drying to a moisture content of 35-40% improves sod handling.

Both drying and coking should proceed slowly as this decreases the production of fines. Higher coking temperatures increase density and decrease coke reactivity.

Peat coke is characterized by a low density, low sulphur content and high reactivity when compared to metallurgical coal cokes. The ash content is dependent on the peat grade, the mineral content of the adjacent mineral earth and on hydrological conditions in the peatland. The electrical resistance of peat coke is fairly high compared to most coal cokes, reducing sharply as the temperature increases.

Peat cokes would not be suitable for blast furnace applications. They are currently used in electric furnaces for silicon production. Their high reactivity and electric resistance characteristics make their use well suited to electric furnaces, although this depends on the furnace end product. Use of peat coke as a replacement for foundry coke is restricted by the high reactivity, and may require cupola modification. Use in direct reduction furnaces and iron ore pelletizing appears technically feasible.

PART 8

PRODUCTION PROCESSES FOR MANUFACTURING PEAT COKE

8.1 INTRODUCTION

This section examines four production processes that could be used to coke peat. Two of these processes, Wielandt and Outokumpu Oy, were in use at the start of 1984, whereas the Lurgi-Salem and Lurgi-Spuhlgas processes are investigated as potential peat coking processes.

8.2 CURRENT PRODUCTION PROCESSES

At the start of 1984 there were two operating peat coking plants in the world, one at Elisabethfehn, West Germany (F.R.G.) and the other at Peraseinajoki, Finland.

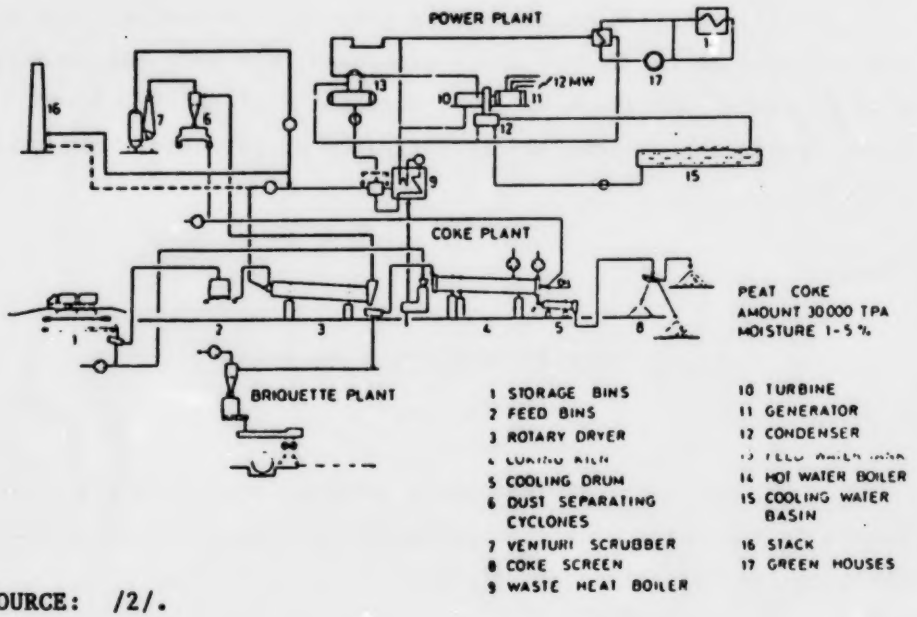
The factory at Elizabethfehn has been in operation since 1905. In Finland, the coke factory designed by Outokumpu Oy has been operating since 1976.

821 THE OUTOKUMPU OY PEAT COKE FACTORY

The design capacity of the factory is 30,000 t/a. Additionally, 40,000 t briquettes and 50,000 MWh electricity per year can be produced. District heat is produced at an output of 20 MW for adjacent horticultural establishments. The process is continuously-operating and its energy yield is 70-80% (coke, briquettes, electricity and district heat included)./1/ The process flowchart of the factory is shown in Figure 8-1 and the material balance is shown in Figure 8-2.

FIGURE 8-1

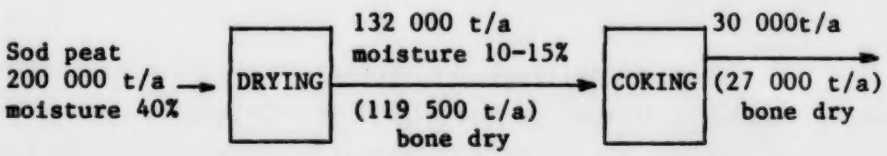
Process Flowchart of the Peat Coke Factory at Vapo Oy



SOURCE: /2/.

FIGURE 8-2

Outokumpu Oy Material Balance



The moisture content of the raw material is 30-40% and sod size 10-100m. The peat is dried to a moisture content of 10-15% with flue gases obtained from coking. During the drying the peat sods shrink considerably and must be dried slowly to reduce cracking. After the drying the peat sods are sieved and the fines are used for manufacturing briquettes. The amount of fines is dependent on the quality of the peat.

Depending on the final product required, the dried peat is coked at 550-900°C in a rotary drum oven employing an updraft principle. The material is fed into the upper part of the rotating drum. In the rotating ovens the heat is transferred into the coking material by radiation. Heat transfer is effective due to the low filling degree and to the movemethe material. The heat required for coking is obtained by burning part of peat volatiles with excess air. If required, additional heat is obtained with the aid of an auxiliary burner, where, for example, cyclone dust can be burnt. No oil is used in the process.

The temperature profile is easily regulated with the aid of auxiliary burners and excess air blowers. It is possible to manufacture coke grades for different purposes in the same unit. In principle, it would also be possible to manufacture activated carbon in this drum.

The pyrolysis gases, which contain tar and particles, are burnt in an after-burner. Part of the heat of the hot (1000°C) gases is used for generating superheated steam in the waste heat boiler, and the rest is used for drying the feed. In the factory power plant the steam is used for producing electricity and district heat.

In principle it would be possible to separate the tars from pyrolysis gases before the combustion without any effect on the energy self-sufficiency. As the tar yield is low and the operation complicated, it is at present more economic to carry out the after-burning without a tar separation and to use the excess heat for producing electricity and district heat. Simultaneously, noxious phenolic compounds are eliminated and no detrimental waste waters are produced.

From the coking drum the coke is fed into the cooling drum, where it cooled by water jets. The coke is then sieved into different fractions before being stored.

822 PEAT COKE FACTORY AT ELISABETHFEHN

The peat coke factory at Elisabethfehn, near Oldenburg in the F.R.G. is owned by Indu-Carbon GmbH. Air-dried sod peat, with a moisture content of 30-40%, produced with a Heseper machine is used as the raw material. The sods differ technically from those made with Finnish machines as the peat is always excavated to a depth of 1.5m and not, as with the Finnish disc machines, to only a depth of 0.5m. For this reason, the decomposition degree and the moisture content of peat are high, which improves the strength of the sods. However, the production costs of sod peat are considerably higher with the Heseper machine than with the Finnish machines. The Heseper machine also requires large united homogeneous peatland areas with a low stump content.

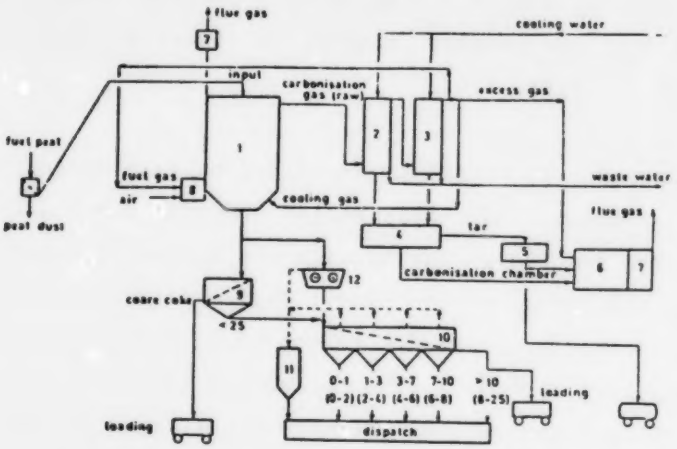
The present production capacity of the factory is about 10,000 t/a, although if there were sufficiently dry raw material available, the production capacity would be 20,000 t/a./3/4/ Tar was recovered earlier, but because the requirements concerning the purification of waste water have become stricter, the tar is burnt to

evaporate waste water./2/ The power plant of the factory was also closed, and today the factory purchases the electricity required. Otherwise the process is totally independent external energy./2/ The process flowchart of the factory is given in Figure 8-3 and the material balance in Figure 8-4.

Using an updraft principle air-dried peat is dried, coked and cooled in nine airtight, indirectly heated retorts, 8.4 x 2.0 x 0.4m, grouped into three sections. The retorts are narrow to guarantee a uniform heating and coking of sod peat. The retorts consist of three zones with no distinct boundaries. In the first zone practically all water evaporates from the peat. The second one is the actual coking zone, where gases and tar evolve. At this stage the sods also shrink significantly, which improves their flow properties in the retort. In the third zone the coke is cooled with cooled gases (25°C) to about 80°C before removal from the retort./3/

The pyrolysis gases are cooled and scrubbed to separate the tar. The tar is burnt together with the excess pyrolysis gases to evaporate phenolic tar water. Part of the cooled, tar-free pyrolysis gases is burnt in separate combustion units under the retorts to generate the heat required, while part is used for cooling the coke. From the combustion units the hot flue gases flow via complicated heating channels through the retorts in such a way that they do not come into direct contact with peat.

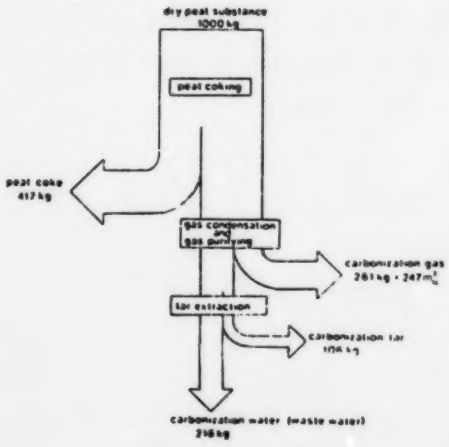
FIGURE 8-3
The process flowchart of the peat coke factory at Elisabethfehn, Oldenburg, F.R.G.



1 = retort, 2 = gas condensation, 3 = gas purifying, 4 = tar extraction, 5 = tar container, 6 = carbonization water combustion, 7 = heat recovery, 8 = combustion chamber, 9 = pre sifting, 10 = sifting, 11 = dust extraction, 12 = coke breaking.

SOURCE: /2/.

FIGURE 8-4
The material balance of the process of the peat coke factory at Elisabethfehn



SOURCE: /4/.

The coking time depends on the moisture content and is 10 - 18 hours./3/ As large peat sods are used as the raw material, the coking time is long. The coke obtained from the large sods is very coarse, more than 75% of coke manufactured is over 30 mm, and contains as large as 30 x 60 x 200 mm coke pieces. The coke is sold in fractions[1] as follows /5/:

Type 0/100 (powder)
Type 02 and 02 coarse
Type 2 - 4, 4 - 8
Type 10 - 30
Type 30 - 150.

The peat coke is used primarily for the production of different silicon metals and for manufacturing activated carbon and graphite. Small amounts of barbeque coke have also been manufactured by briquetting the smallest fraction using starch as a binder./3/

The Wielandt process is reliable in operation and in 30 years the factory has never been shut down, one or two sections have always been in operation./3/ However, the instrumentation and operation of the factory is rather antiquated, expecially in regard to modern labour safety requirements. For example, the feed and discharge are carried out manually.

823 PEAT COKING PROCESSES UNDER DEVELOPMENT

.1 Lurgi-Salem Hearth Oven

The hearth oven developed by the Salem Furnace Corporation, Pittsburgh, USA, has been used for coking high volatile bituminous

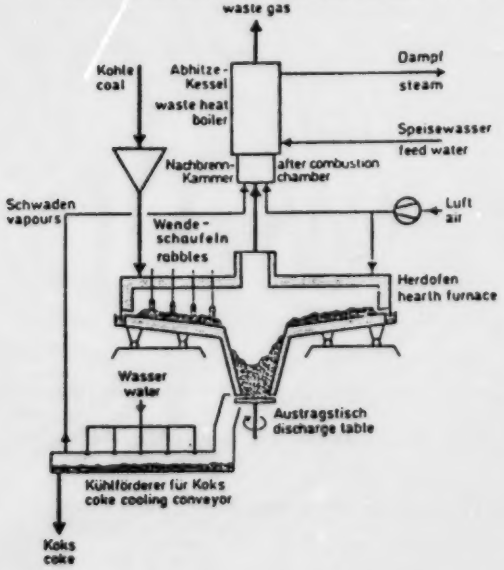
[1] For example: Type 30-150 means that coke sizes range from 30 mm to 150 mm.

coal to produce the so-called nut coke for phosphorus electric ovens. Lurgi GmbH in Frankfurt am Main, F.R.G., has constructed under license a large hearth oven for coking predried browncoal, and a medium-sized hearth oven in Zambia for coking low volatile bituminous coal./6/ Lurgi GmbH proposed at an international peat symposium in Bad Zwischenahn, F.R.G., in 1979 that the hearth oven could also be used for coking sod peat./7/ However, no laboratory experiments with peat have been carried out so far.

The process flowchart of a hearth oven with equipment for the recovery of waste heat is shown in Figure 8-5. The hearth is inclined toward the centre and rotates at 5-20 r/min. Predried sods are fed via two feed pipes to the outer edges of the hearth as a 50-150mm thick layer. The thickness of the layer is regulated by adjusting the height of the feed pipe. The maximum piece size of the feed is about 60mm. The material flows slowly toward the centre of the oven with the aid of stationary water-cooled rabbles.

FIGURE 8-5

The process flowchart of a hearth oven equipped with the recovery of waste heat



SOURCE: /8/.

The sods are dried and volatiles are burnt by blowing air through nozzles installed at the circumference of the oven. The temperature of the oven rises to 1300-1500 °C and the feed is heated by radiation to about 950 °C. As in the method developed by Outokumpu Oy, the volatile substances from the feed material are also burnt to develop the heat required. If the content of volatiles of the feed is 15% and the moisture content 35%, no auxiliary fuel is needed. /6/

When the volatile substances burn above the hearth, all hydrocarbons are decomposed. After the furnace the pyrolysis gases contain only CO and H_2 and are burnt in an afterburner. The energy contained in the flue gases can be recovered in a waste heat boiler. The amount of steam generated is dependent on the amount of volatiles and varies from 0.8 to 3.3 t/t coked material./6/ The coke is withdrawn via a discharge table and cooled with a direct water jet to 250-300 °C and with air to 50 °C before sieving. The residence time can be varied over a wide range, but, for example, the coking of browncoal usually only takes one hour.

The largest type of hearth oven could treat about 800 t predried sod peat a day. The capacity of smaller types is about 20% of this./7/ No experiments have been made with sod peat in a hearth oven, and hence, there is no knowledge about its suitability for peat. However, it can be expected that for a residence time of 1 h the rate of temperature rise is too high for peat and that peat sods would crack. The residence time can be increased, but the capacity would then be reduced. In addition the smaller size of the hearth oven gives poor control over the heating rate and, as a consequence, the crushing of sods is higher.

.2 Lurgi-Spuhlgas Process

The Lurgi-Spuhlgas process has been used for about 40 years to coke lignite and bituminous coals. About 250 large units have been

built throughout the world. The latest plant was erected in India in 1967. The process was developed primarily for the recovery of liquid carbonization products, but according to Lurgi it might also be suited for coking predried sod peat. However, no experiments have been made with peat.

The method differs from that of Wielandt in that it employs direct heat transfer via hot inert gases. The feed must be dried to a residual moisture content of 15%; otherwise the water content of the gas is too high./7/ The flowchart of the process is given in Figure 8-6.

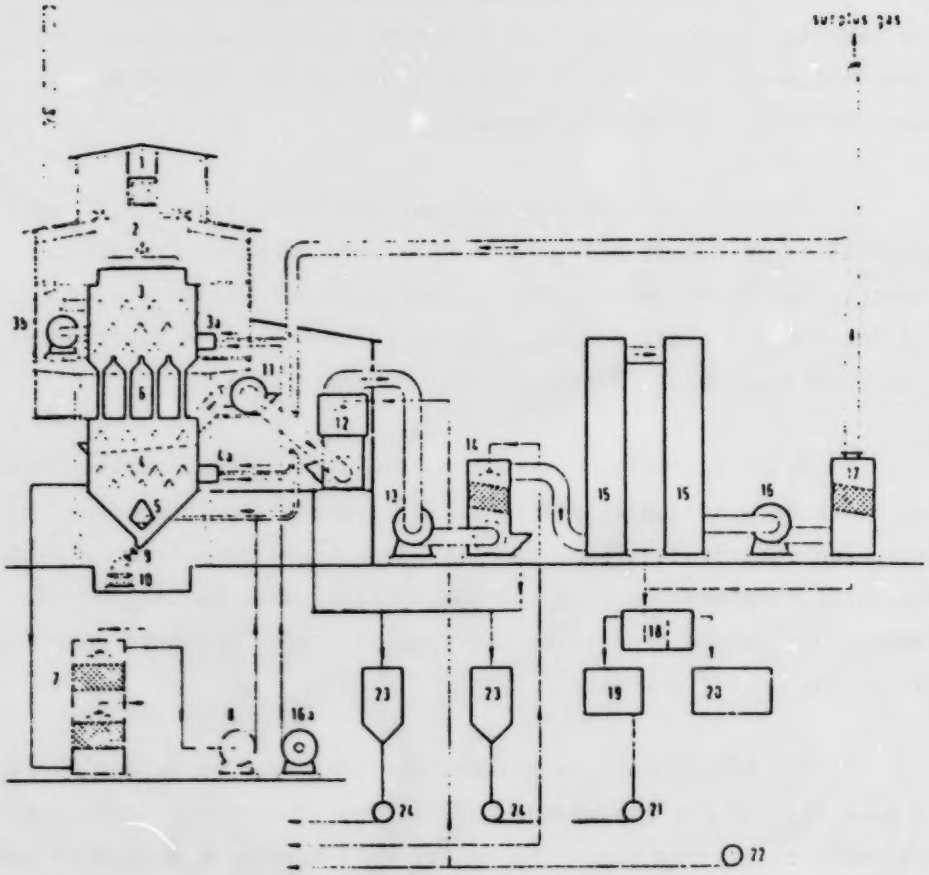
There are three distinct zones in the shaft furnace: drying, coking and cooling. The heat required for drying and coking is obtained by mixing the material with hot gases generated in separate combustion chambers. Cooled, tar-free dry pyrolysis gases are used as the fuel in these combustion chambers. The excess gases are led from the drying zone to the stack, and hence, the peat moisture leaves the system as steam and is not condensed. No data are available on the environmental effects of the gas.

The pyrolysis gases from the coking unit are cooled in stages. In the first stages of lignite coking, water-free heavy tar oil and gas water are separated from each other. Most of the cooled and purified gas is recirculated. It functions as a coolant in the cooling zone of the shaft-furnace, is heated again and then mixed with the hot flue gas coming from the combustion chambers to achieve the required coking temperature. The pyrolysis gases flow countercurrent to the material flow. The excess gas can be used for drying the feed.

It would be possible to coke about 400 t/d sod peat in the Spuhlgas process./7/

FIGURE 8-6

The process flowchart of the Lurgi-Spuhlgas process



1 = bucket conveyor, 2 = movable charger, 3 = drier, 3a = drier combustion chamber, 3b = drier circulation fan, 4 = carbonizer, 4a = carbonizer combustion chamber, 5 = coke cooling zone, 6 = connecting ducts, 7 = spray cooler, 8 = cooling gas fan, 9 = discharge lock chamber, 10 = conveyor, 11 = dust separator, 12 = precooler, 13 = hot gas fan, 14 = hot tar washer, 15 = cross-tube cooler, 16 = cold gas fan, 16a = air-fan, 17 = mist separator, 18 = separating tank, 19 = middle oil tank, 20 = gas liquor tank, 21 = pump for middle oil, 22 = pump for gas liquor, 23 = tar tank, 24 = pump for tar.

SOURCE: /7/.

8.3 SUMMARY

The Outokumpu Oy process has been operating since 1976. The raw material is peat sods with an annual production capacity of 30,000 tonnes of peat coke, 40,000 tonnes of briquettes, 50,000 MWh of electricity and 150 MWh of thermal heat.

The Wielandt process has been operating since 1905. The raw material is peat sods produced by a Heseper machine. Production capacity is 20,000 tonnes of peat coke. Peat tars used to be collected but are now burned. The large Heseper sods give larger peat coke fractions, with 75 percent over 30 mm in size.

The Lurgi-Salem hearth has been used to coke various coals and has been proposed as a peat coking oven, although no experiments have been conducted. The effective capacity of this oven is decreased when producing peat coke as the coking times must be lengthened. Poor temperature control increases the possibility of crushing peat sods during the coking process.

The Lurgi-Spuhlgas process has been used for about 40 years to coke lignite and bituminous coals. The process was developed primarily to recover tars. No experiments have been made with peat.

PART 9

PEAT COKE PRODUCTION COSTS

9.1 INTRODUCTION

Three peat coking processes are examined: the Outokumpu Oy, Wielandt and Lurgi-Salem hearth. Mining costs and the impact of mine development on peat coke production are investigated. Minimum revenues required to cover incremental costs associated with the power plant and briquetting plant are estimated. The cost/tonne of peat coke required to recover capital and operating costs are estimated for the three processes. Peat coke prices are then compared to 1983 prices for coal coke. The level of subsidies required to reduce peat coke to coal coke price levels are examined.

911 ASSUMPTIONS AND METHODOLOGY

The manufacturing and operating cost data supplied by VTT was converted from Finnish currency to Canadian dollars at current exchange rates. These costs were combined with Monenco estimates of sod peat mining costs to generate Canadian peat coke production costs. These costs are considered accurate to plus or minus 30 per cent.

In developing equivalent annual costs from these estimates, no allowances have been made for escalation in equipment or operating costs. Thus all costs are in terms of 1984 dollars. The coking facility was assumed to be located at the peat bog, eliminating sod transportation costs, and have a 20 year service life. The calculations for the cost/tonne of peat coke include those which are necessary to recover capital and operating costs. Not included are land acquisition, royalty fees, licensing fees, packaging costs, and transportation costs to the end user.

Appendices D1 to D5 show capital and operating costs for the three processes. Additional assumptions and explanatory notes are shown in Appendix D6.

9.2 MINING

Mining costs are based on a 120,000 tonne/year sod peat mine and have been scaled up or down to suit the feed volumes required by the various processes. The Outokumpu Oy and Lurgi-Salem processes each require 200,000 tonnes of sod peat annually and the Wielandt process requires 60,000 tonnes of sod peat when operated at capacity. Increased costs for peat sod production using the Heseper machine (see Section 822) have not been included for the Wielandt process.

According to recent Monenco studies, three years are required to prepare a bog before sod peat production can begin. Sod output increases slowly as more bog area is brought into production. Thus peat coke production is assumed to start in year 3 of the sod peat production, and the costs of the first two years of peat sod production are assumed to be capitalized as start-up costs. Under this scenario the costs associated with sod mining at full production are: Outokumpu Oy and Lurgi Salen, $21/tonne of sod peat and Wielandt $40/tonne of sod peat.

9.3 PEAT COKE PRODUCTION

931 OUTOKUMPU OY PROCESS

This process is described in Section 821. Production costs were estimated under three scenaria. In the first scenario it was

TABLE 9-1

Cost Summary for Outokumpu Oy Process

Description	a Peat Coking	a+b (Power Station)	a+b+c (Briquetting Plant)
Coke Production (k.tonnes)	28.5	28.5	28.5
Briquette Production (k.tonnes)			40.0
Thermal Power (MWh)		150	150
Electric Power (MWh)		50	50
Total Manpower[1]	10	15	25
Capital Cost Recovery ('000$)	3,475	5,448	6,199
Operating Costs ('000$)	4,012	4,913	5,473
Total Costs ('000$)	7,488	10,361	11,672
Less Revenue ('000$)[2]	0	4,250	6,530
Costs to be Recovered by Peat Coke ('000$)	7,488	6,111	5,142
Peat Coke $/tonne	263	214	180
Total Capitalized (Millions$)	20.8	32.9	37.9

NOTES: Figures taken from Appendix D1, D2 and D3, and are for processes at full production.

1) Does not include mining personnel, quality control or administration personnel.
2) Briquettes assumed to sell for 3.25$/$10^6$ BTU.
   - Thermal power assumed to sell for 2.0¢/KWH.
   - Electric power assumed to sell for 2.5¢/KWH.
   - see Appendix D6.

assumed that only the peat coke plant was built. In the second and third scenaria the power plant was added and, in the third scenario the briquetting plant was also added. Operating and capital costs, assuming full production, are summarized in Table 9-1.

The minimum cost at which peat briquettes could be sold to recover the incremental capital and operating expenses associated with their manufacture would be $\$1.95/10^6$ BTU. This assumes no mining costs are allocated to briquette production and 40 kilotonnes of briquettes are produced and sold per year. The minimum cost at which electric and thermal power could be sold to recover their incremental capital and operating expenses associated with their manufacture would be 1.62¢/KWH for electric power and 1.35¢/KWH for the thermal power. This assumes no mining costs are allocated to power production, 50 MWH of electric and 150 MWH of thermal power are produced and sold per year, and that the ratio between electric and thermal power revenue is 1.25.

Assuming that briquettes can be sold for $\$3.25/10^6$ BTU, electric power can be sold for 2.5¢/KWH, and thermal power can be sold for 2.0¢/KWH (see notes 9, 10, and 11, Appendix D6), the addition of the power station increases capital and operating cost by $2.87 million per year, provides a revenue of $4.25 million per year, thus reducing unrecovered costs by approximately $1.40 million per year. The addition of the briquetting plant increases capital and operating costs by $1.30 million per year, provides an incremental revenue of $2.28 million per year, thus further reducing unrecovered costs by approximately $0.97 million per year. Under these revenue assumptions the price of peat coke ranges from $180 to $263 per tonne.

Without the briquetting plant, the accumulating peat fines are assumed to be used for firing the coking drum with the remainder disposed of at zero cost. Given that a market can be developed for

peat coke fines, the incremental benefit of adding the briquetting plant would be reduced.

The sale of electricity and thermal power assumes that users of thermal power i.e., greenhouses would locate next to the coking plant, and that no pipeline costs are encountered. Both of these factors are site specific. If suitable thermal power users are not found and if pipeline costs are encountered, then the incremental benefit would be reduced. Consequently, the net cost of peat coke associated with the power plant and briquetting plant would have to be revised upward. Thus the peat coke prices calculated should be taken as the lower end of the range expected.

932 WIELANDT PROCESS

This process is described in Section 823. The recovered peat tar is assumed to be sold as furnace oil based on the heat content. This generates a revenue of approximately $47/tonne (see note 12 Appendix D6). In this scenario the price of peat coke to recover operating and capital costs at full production is $393/tonne (see Appendix D4).

The Wielandt process has the highest coking capital costs per unit output of peat coke, which at $198/tonne is 160 percent greater than the equivalent Outokumpu Oy costs ($122/tonne for the process which does not include a power station or briquetting plant).

933 LURGI-SALEM PROCESS

This process is described in Section 824. The material balance is identical to the Outokumpu Oy process, except for a larger percentage of fines production. The greater investment required for

the hearth oven by comparison to the Outokumpu Oy coking drum ($11.5 million versus $5.06 million) requires correspondingly higher peat coke prices to recover capital costs. A Lurgi-Salem plant including the power station requires $274/tonne to recover capital and operating costs, an increase of approximately $60/tonne over the equivalent Outokumpu Oy price (see Appendix D5).

9.4 COKE PRICES

The average prices of U.S. coke in 1983 (converted to $Can./tonne) are shown in Table 9-2. The import price of U.S. coke in Canada averaged $141/tonne in 1983, a slight increase from the $139.41/tonne in 1982./7/ West German coke was imported into Canada for the first time in 1983./7/ Canadian supply shortages meant that the price reduction for industrial coke seen in the U.S. was not passed on to Canadian consumers.

Petroleum cokes experienced a significant price reduction in 1982, dropping 40 percent from $60 U.S./short ton to $35 U.S./short ton. It appears that the aluminum industry cutbacks reduced the demand for this grade of coke./2/

TABLE 9-2

Coke Prices in the U.S.A.

	Average Price Can. $/Tonne Jan.-Sept. 1982	Jan.-Sept. 1983
All Coke	115	114
by Consumer Category:		
Blast Furnace	153	153
Foundries	193	183
Other Industrial Use	129	115
Breeze Total	44	43

NOTES: 1. FOB value.
2. Conversion U.S. $/short ton x (1.1 tonne/short ton x 1.2 Can. $/U.S.$).

SOURCE: /1/.

If the use of peat coke in some electric furnaces offers a 12% to 15% reduction in electricity consumption, it follows that a price premium for peat coke should be possible (see Section 7.3). A 20 MW furnace, the standard for the silicon industry /3/, assumed to consume approximately 50,000 MWH[1] per year would save between 6,000 to 7,500 MWH of electricity per year. At an average cost of 2.0¢/KWH this represents a saving of $120,000 to $150,000 per year. Assuming consumption of 5-10,000 tonnes of coke, a saving per tonne or price premium that could be supported for peat coke would be between $12 to $30 per tonne. Therefore, if peat coke could be marketed at $140/tonne it would be comparable in price to the imported U.S. coal coke and still offer the savings calculated above.

The minimum capital subsidies required to lower the capital and operating cost recovery price of peat cokes are shown below.

[1] 20 MW x 15 hours/day x 220 days/year x 0.80% utilization = 50,000 MWH/year.

Minimum Capital Subsidies Required to
Reduce Peat Coke to $140/tonne

Process	% Subsidy	$ (millions)
Outokumpu Oy:		
Peat Coking	not possible[1]	-
Peat Coking & Power Plant	39	12.8
Peat Coking & Power Plant & Briquette.	19	7.2
Wielandt Process:	not possible[1]	-
Lurgi-Salem	54	21.9

[1] not posible, as in addition to capital subsidy, would also require operating cost subsidies to bring prices down to this level.

9.5 SUMMARY

Mining costs are based on applying production ratios to the costs of a 120,000 tonne/year sod peat mine. This indicates that sod peat would cost approximately $21/tonne as input to the Outokumpu Oy process or the Lurgi-Salem process and $40/tonne for the Wielandt process. Use of the Heseper machine would increase the sod peat costs for the Wielandt process.

The minimum by-product prices for capital and operating cost recovery breakeven for the power plant and briquettting plant in the Outokumpu Oy process, based on a 30,000 tonne peat coke capacity, are:

Electric power - 1.69¢/KWH
Thermal power - 1.35¢/KWH
Briquettes - 1.95$/$10^6$ BTU

Assuming that the following revenues can be obtained:

Electric power - 2.5¢/KWH
Thermal power - 2.0¢/KWH
Briquettes - 3.25¢/10^6 BTU

The cost recovery (capital and operating) prices for the 30,000 tonne per year of peat coke in the Outokumpu plant are:

peat coking plant	$263/tonne
peat coking plant and power station	$214/tonne
peat coking plant, power station and briquetting plant	$180/tonne

These costs do not include land acquisition, royalty fees, licensing fees, packaging costs and peat coke transportation costs.

The equivalent capital and operating cost recovery price of the peat coke from a 15,000 tonne plant based on the Wielandt process is $393/tonne. Use of the Heseper machine for sod peat production would increase this price. The Wielandt process has the highest capital cost/tonne of the three processes investigated.

The Lurgi-Salem capital and operating cost recovery price of peat coke is $274/tonne for a plant that includes a power station and has a 30,000 tonne annual peat coke production capacity.

To lower the capital and operating cost recovery price of peat coke to $140/tonne, comparable to current prices of coal coke

from the U.S., would require minimum capital subsidies ranging from $7-13 million for the Outokumpu Oy process and between $22 million for the Lurgi-Salem process. Capital subsidies could not lower the Wielandt process capital costs sufficiently to provide an operating cost breakeven at current market prices. When land acquisition, royalty fees, etc. are added, the subsidies would have to be increased further.

PART 10

CURRENT PRODUCERS AND CONSUMERS OF CARBON PRODUCTS IN CANADA

10.1 INTRODUCTION

This section examines current production and demand of carbon products in Canada. Where possible, users are identified both by industry and geographical bases.

Information about the carbon black market is presented even though the use of peat as a feedstock is not considered feasible at this time (see Sections 4 and 6).

10.2 COKE

1021 PRODUCTION OF COAL COKES

Metallurgical cokes are produced by Canada's four integrated iron and steel manufacturers, which appear to consume most of this production internally in blast furnaces. See Table 10-1 and Table 10-2 for coke oven capacity and production.

As every tonne of pig iron produced in a blast furnace requires approximately 0.5 tonnes of coke, Canadian coke oven capacity is well suited to blast furnace capacity.

As can be seen, production has fallen since 1979, reflecting the reduced demand for steel, with production averaging less than 40 percent of capacity in 1982.

TABLE 10-1

Canadian Coke Ovens and Blast Furnace Capacity
as of January 1, 1983

Firm	Coke Ovens		Blast Furnaces	
	# in use	annual capacity	# in use	annual capacity
		kilotonnes		kilotonnes
Algoma Steel Corporation	203	1,009	2	1,649
Dofasco Inc.	246	1,540	3	2,792
Stelco Inc.	392	2,792	5	5,070
Sydney Steel Corp.	26	130	1	396
TOTAL	867	5,471	11	10,507

SOURCE: /5/.

TABLE 10-2

Canadian Coal Coke Production

Year	Production
	kilotonnes
1975	5278
76	5289
77	4845
78	4968
79	5775
80	5250
81	4659
82	3999

SOURCE: /6/.

1022 FEEDSTOCKS

In 1980, only 13 per cent of the coal utilized in coking plants was sourced in Canada. The remaining 87 per cent was imported from the United States. Sydney Steel Corporation used mostly Canadian coal, Dofasco and Stelco used some Canadian coal, and the Algoma Steel corporation used imported coal./1/

Canadian production of coking coals has recently increased, with most of the increased production destined for export to Japan. The long distances involved in bringing Western coal to the Eastern coke producers, make their economic use unlikely. Therefore, users will more than likely continue to import their coking coals, although Canada is currently a net exporter of coking coals.

1023 PETROLEUM COKE PRODUCTION

Petroleum coke is produced in Canada and most of the production is consumed by the producers. Petroleum coke is burned when re-activating the catalyst used in cracking crude petroleum, providing energy for the refineries. This reduces the quantity available for anode manufacture and metallurgic use.

Canada Petroleum Coke Production

YEAR	TOTAL PRODUCED	AVAILABLE
	kilotonnes	
76	570.4	215.8
77	774.7	201.6
78	852.6	199.9
79	818.8	193.6
80	856.6	193.6
81	814	206
82	802	166.8

SOURCE: /6/.

.1 Imports and Exports of Coal Coke

Import levels have fluctuated from 287,249 tonnes in 1976 to 626,923 tonnes in 1980. In 1982, Newfoundland and New Brunswick imported all of their coke although Quebec and Ontario accounted for almost 60 per cent of the imports. Certain grades of coke, for example foundry coke (see Section 2, .4), are not manufactured in Canada. Chemical manufacturers and ore smelting operators in Newfoundland and New Brunswick buy U.S. coke produced in the U.S.

Exports have ranged from 14,400 tonnes in 1982 to 319,554 tonnes in 1980. Most of this coke is exported to Japan from coking facilities operated by Kaiser Resources. Low demand in Japan has resulted in the shutdown of this coking plant.

Canadian Imports & Exports of Coal Coke

Year	Imports	Exports
	kilotonnes	
1975	546.4	96.0
76	287.2	169.9
77	382.8	198.7
78	482.8	217.6
79	520.5	228.6
80	626.9	319.6
81	304.9	67.6
82	337.4	14.4

SOURCES: /1/ for years 1975-80.
/16/ for years 1981-82.

.2 Imports and Exports of Petroleum Coke

Imported petroleum coke originates primarily in the United States, a country which represents over 80 per cent of world capacity. These imports showed a dramatic decline in 1982, possibly in part resulting from the reduced production in the aluminum industry.

Petroleum Coke Imports & Exports

Year	Imports	Exports
	kilotonnes	
1975	572.6	161.6
76	591.9	137.0
77	986.7	157.2
78	974.0	134.8
79	980.7	125.4
80	908.3	150.2
81	915.7	-
82	555.1	-

SOURCE: /1/ for years 1975-80.
/6/9/ for years 1981-82.

1024 CONSUMPTION OF COKE IN CANADA

Statistical information is summarized in Table 10-3 for the use of coal coke in Canada, tabulated according to the energy use of the coke. The largest user was the iron and steel industry, which consumed over 88 per cent in 1982.

Tables 10-4 and 10-5 show the non-blast furnace consumption in the steel industry and the chemical industry.

The consumption of petroleum cokes is shown in Table 10-6. Although 673,000 tonnes were consumed in 1982 in non-energy uses, this consumption is not identified. Telephone communication with representatives of Statistics Canada indicated that the aluminum industry is the largest user, accounting for the majority of the 673,000 tonnes.

TABLE 10-3

Use of Coal Coke in Canada

Disposition	Quantity in kilotonnes 1980	1981	1982
Used for Energy:			
Iron Mines	87.0	118.2	102.9
Iron & Steel	4,959.7	4,410.2	3,844.7
Smelting & Refining	81.4	84.5	90.7
Cement	-	5.7	48.0
Other Manufacturing	93.8	97.0	87.6
Non Energy Use:	-	146.9	180.6
TOTAL	5,221.9	4,862.5	4,354.5

SOURCE: /6/.

TABLE 10-4

Non Blast Furnace Coke Used in Iron & Steel Industry

Disposition	Quantity in tonnes 1980	1981
Ferro-Alloy[1] Manufacture	318,189	82,605
Foundry Coke[2] (Used in Cupola)	67,554	63,050
Steel[3]	26,683	35,330
Sinter Plants[1]	- CONFIDENTIAL -	
TOTAL	412,426	180,985

SOURCES: 1) Statistics Canada, Catalogue 41-203, 41-231.
2) Statistics Canada, Catalogue 41-226.
3) Statistics Canada, Catalogue 45-002.

TABLE 10-5

Coke Used by Industrial Chemical Producers

Disposition	Quantity in kilotonnes 1980	1981
Industrial Chemicals	178,064	155,346

SOURCE: /7/.

TABLE 10-6

Petroleum Cokes

Disposition	Quantity in kilotonnes 1980	1981	1982
Used For Energy:			
Cement	28.5	110.0	55.5
Others	-	-	33.1
Non Energy Use:	236.2	848.5	584.4
TOTAL	264.7	958.5	673.0

SOURCE: /6/.

.1 Geographical Breakdown

The geographical distribution of various coke users is shown in Table 10-7. The following information was obtained for some of the major end uses of coke in Canada.

Blast Furnaces:

The only electric blast furnaces were operated by QIT-Fer et Titane Inc. (QIT) in Quebec. With 600,000 tonnes capacity the company accounts for less than 6% of Canadian pig iron capacity. Of the remaining four integrated steel producers, only Sydney Steel Corporation is located out of Ontario.

Steel Producers:

Electric furnaces account for 5,390,000 tonnes of the total Canadian capacity of 21,295,000 tonnes for the production of steel ingots, or 25% of total production. As can be seen in Table 10-8, outside of Ontario and Nova Scotia, all steel ingot and castings are produced in electric furnaces.

Assuming that coke consumption per tonne of steel is averaged across all electric oven steel producers, the geographical breakdown of this coke market is shown in Table 10-9.

Iron Foundries:

The geographical distribution of the iron foundries is shown in Table 10-7. In 1981, Statistics Canada showed a total of 110 establishments. Given that foundry coke represents approximately 6% of materials and supplies used (Statistics Canada information) and assuming that all foundries use cupolas to melt the feedstock, the approximate 1981 market in Canada is shown in Table 10-10. The cost of foundry coke has increased from $199/tonne in 1979 to $257/tonne in 1982./8/

TABLE 10-7

Geographical Distribution of Coke Consumers

Description of Consumer	New Foundland	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
Steel:									
Blast Furnaces[1]		1		1	3				
Steel Electric Furnaces[1]		2		11	12	2	1	4	5
Iron Foundries[3]		1	1	14	35	3	2	5	2
Sinter[1]					2				
Direct Reduction[1]				1					
Smelting & Refining:[2]									
Primary Reduction			1						1
Aluminum[2]				2					1
Titanium[2]				1					
Silicon & Ferrosilicon[2]				3					
Carbides[2]				3	4				
Chemical:									
Phosphorus[2]	1			1					
Calcium[2]					1				
TOTAL	1	4	2	37	57	5	3	9	9

SOURCES: 1) Statistics Canada. Catalogue 41-001.
2) Canadian Mineral Yearbook, 1980.
3) Statistics Canada Catalogue 41-226.

TABLE 10-8

Geographical Analysis of Steel Producers Capacity
January, 1983

(tonnes)

Province	Total Steel Ingot Capacity	% Electric Furnace	Steel Casting[1] Capacity
Nova Scotia	810,000	0	3,000
Quebec	1,969,985	100	170,111
Ontario	17,007,890	11	154,911
Manitoba	275,000	100	84,400
Saskatchewan	700,000	100	---
Alberta	392,150	100	12,000
British Columbia	140,000	100	47,022

NOTE: 1) By electric furnace.

SOURCE: /5/.

TABLE 10-9

Geographical Distribution of Steel Coke Market
Based on 1983 Capacity of Electric Furnaces

Province	% of Market
Quebec	36.8
Ontario	34.8
Manitoba	6.2
Saskatchewan	12.0
Alberta	6.9
British Columbia	3.2
Others	0.1
TOTAL	100.0

TABLE 10-10

Foundry Coke Market Distribution
Based on 1981 Consumption Data

Province	# of Establishments	'000 $	%
Nova Sotia	3	86	0.6
Quebec	28	3,240	22.5
Ontario	56	9,403	65.4
Manitoba	4	307	2.1
Saskatchewan	2	-	-
Alberta	6	990	6.9
British Columbia	9	360	2.5
TOTAL		14,386	100.0

SOURCE: /8/.

Direct Reduction:

Sidbec Dosco will be investigating substituting a portion of their natural gas consumption with electricity or completely replacing natural gas with a mixture of electricity and coal in their direct reduction furnace./2/

Titanium:

QIT - Fer et Titane Inc. (QIT) is the only company that processes titanium ore in Canada. The company uses electric smelters in its plant in Quebec.

Silicon:

The Canadian ferro silicon and silicon industry is centered in Quebec primarily due to the low cost electrical power. SKW Canada

Inc., Union Carbide Canada and Chromasco are the three producers.

Calcium:

Chromasco, one of three producers of Calcium in the western world, operates a plant located in Ontario.

Aluminum:

There are two producers in Canada, Reynolds and Alcan. A recent agreement between Pechiney and the Quebec Government to start a new smelter at Becancour will mean a capacity increase. This in turn, should increase the demand for anode coke.

Phosphorus:

Erco Industries operates two plants producing phosphorus, one each in Newfoundland and Quebec.

Smelting & Refining:

There are two companies that have primary reduction plants: Brunswick Mining in New Brunswick and Cominco in British Columbia.

Sinter:

Statistics Canada showed only two sinter plants operating as of January 1, 1983. These are owned by the Algoma Steel Corporation and Stelco.

10.3 ACTIVATED CARBON

1031 ACTIVATED CARBON PRODUCTION

A. C. Carbone, located in Quebec, is the only producer of activated carbons in Canada. Annual capacity of the plant is approximately 450 tonnes. The plant has been in operation since 1962, and can produce up to 145 grades of activated carbons using coconut husks as the primary feedstock.

1032 ACTIVATED CARBON IMPORTS

Imports supply the rest of Canada's activated carbon demand. The volume, country of origin and import share are shown in Table 10-11. As can be seen, West Germany and the Netherlands appear to be rapidly gaining market share at the expense of the United States. Growth appears to have stabilized in 1978, and the import level has since remained at an almost constant level of just over 5,000 tonnes. According to industry sources, inventory levels are very high. This may account for the slight fall off in supply in 1983, as inventory was possibly drawn down. At the same time the inventory buildups may account for the rapid increase in imports from W. Germany and the Netherlands. The low prices of the Netherlands activated carbons in 1982 may also account for their market share increase.

The average import prices for activated carbons are shown in Table 10-12 for 1982. Although growth in quantities stabilized in 1978, the cost/kg has steadily increased, averaging 13% per year from 1976 to 1982. This has meant a growth in the dollar value of activated carbon imports to the $8.4 million of 1982, as can be seen in Table 10-13.

TABLE 10-11

Active Carbon Imports (tonnes & % of market)

Country of Origin	1976	1977	1978	1979	1980	1981	1982
United Kingdom	215	161	261	331	220	270	215
	7%	4%	5%	7%	4%	5%	4%
West Germany	-	-	-	14	71	199	423
				-	1%	4%	8%
Netherlands	471	359	289	0	0	315	767
	13%	9%	6%			6%	15%
Sri Lanka	-	-	-	-	-	-	3
							0%
Japan	-	-	-	-	-	97	82
						2%	2%
U.S.A.	3,010	3,381	4,548	4,352	4,508	4,495	3,691
	80%	85%	88%	83%	87%	84%	71%
TOTAL	3,745	4,000	5,158	5,158	5,190	5,377	5,184

NOTE: - does not include pre-fabricated filters which may incorporate activated carbon.
- does not include output of Canadian manufacturer.

SOURCE: /9/.

TABLE 10-12

Average Price For Activated Carbon in 1982

Country of Origin	Prices: 1982 $/kg
U.K.	1.22
Germany	2.14
Netherlands	0.90
Sri Lanka	1.18
Japan	3.82
U.S.A.	1.69
Weighted Average	1.62

Data from Table 9-11

TABLE 10-13

Activated Carbon Prices Historic Trend

Year	Average Price ($/kg)	TOTAL $'000
1976	0.769	2.881
1977	0.836	3.345
1978	0.880	4.541
1979	1.059	5.462
1980	1.307	6.786
1981	1.393	7.489
1982	1.621	8.400

Data from Table 9-11.

1033 CONSUMPTION OF ACTIVATED CARBON

Statistical information on the end uses of activated carbon is generally not available. This is a consequence of the large number of users and the small quantities consumed.

Statistics Canada publishes activated carbon use by the cane and beet sugar processors.

Cane and Sugar Beet Industry Consumption of Activated Carbon

Year	# of Establishments	Quantity (tonnes)	Cost ('000 $)	$/kg
1981	12	1,830	1,088	0.59
1982	12	2,413	1,486	0.62

SOURCE: /10/.

In 1982 these industries accounted for 46% consumption on a volume basis. The average price of 0.62$/kg is significantly less than the national imported average of 1.62$/kg (see Table 10-12) demonstrating that either the lower cost powdered carbons are being used or the users are getting significant volume price discounts.

Conversations with various distributors of activated carbons indicated that:

- activated carbons are normally distributed in 20-50 kg bags;
- certain grades and end uses, i.e., aquarium carbons for homes, are shipped in much smaller quantities and can retail at up to $16.00/lb;
- re-order quantities tend to be small with intermittent timing;
- each manufacturer has a small menu of grades, providing specialized products.

10.4 TARS

1041 TAR PRODUCTION

The production of coal tars, a by-product of the coal coking process, by the integrated steel producers is inelastic with respect to its price as production depends on the demand for blast furnace coke (see Section 6). Statistics Canada states that 1980 shipments of coal tar and pitch was $58 million./11/ The actual quantity shipped was not identified.

1042 TAR CONSUMPTION

The wide variety of chemicals that can be extracted from coal tar and the structure of the re-processing channels makes it difficult to identify tar users. The differences between peat and coal tars, which do not appear to be fully understood at this time, suggests that coal tar users may not be able to substitute peat tars in their existing process.

The only industry where coal tar consumption was identified is the "miscellaneous chemical industry"[1]. The value of 1980 consumption was $13.5 million increasing to $36 million in 1981./2/

1 Defined by Statistics Canada as: "This industry comprises extablishments primarily engaged in manufacturing chemical products not elsewhere classified, such as explosives, ammunition, insecticides, germicides, matches, adhesives, polishes and dressings. This industry includes establishments primarily engaged in manufacturing deodorants and disinfectants for household, institutional or industrial use; sweeping compounds and dry cleaning preparations." SOURCE: /12/.

The literature indicated that the pitch remaining from distillation of coal tars is used in aluminum smelters and other similar industries as an input to anode production. Statistics on the size of this market are not available. The main users would be the aluminum smelting industry in Quebec and B.C.

In 1981 asphalt consumption was 3,764,000 tonnes[1] with 395,200 tonnes being used by roofing manufacturers./13/ Asphalt accounted for over 46 percent of the raw material cost for these roofing manufacturers. Their 1981 volumes declined 27 percent from 1980, although asphalt prices per tonne increased over fifty percent to $196 per tonne./14/

10.5 WAXES

1051 WAX PRODUCTION

Of the total range of wax types, only petroleum and synthetic waxes are manufactured in Canada. An independent wax producer is International Waxes Limited of Ontario which operates one of the largest petroleum wax refineries in North America. The production of this refinery includes paraffin waxes, micro-crystalline waxes and petrolatum (refined to high quality U.S.P grades for the cosmetic, pharmaceutical, baking and food processing industries).

The other producers, the integrated petroleum refineries, have the capability of manufacturing waxes to meet perceived demand or, if insufficient demand is anticipated, the wax can be re-processed to make other products. This flexibility makes the production extremely demand sensitive.

1052 IMPORTS

The imports of carnauba and montan waxes are shown in Table 10-14. Some carnauba waxes, although originating in Brazil, are imported through the U.S.A. The price averaged $2.69/kg in 1979 falling to $2.61/kg in 1983. The total tonnage has dropped from 149.7 tonnes in 1979 to 142.5 tonnes in 1983. The quantity of montan waxes was not recorded by Statistics Canada, however, the dollar value of the montan wax market decreased from $727,000 in 1980 to $481,000 in 1983. In 1983, China exported montan waxes to Canada for the first time.

TABLE 10-14

Canadian Imports of Carnauba and Montan Waxes

(Thousands of Dollars)

	1980	1981	1982	1983
CARNAUBA:				
Brazil	182	133	92	128
U.S.A.	160	261	240	245
U.K.	---	---	6	---
Switzerland	---	8	---	---
TOTAL	342	402	338	373
MONTAN:				
China	---	---	---	2
West Germany	124	93	205	182
East Germany	---	15	---	---
U.S.A.	563	351	259	296
TOTAL	727	459	464	481

SOURCE: /9/.

1053 WAX CONSUMPTION

Consumption of carnauba and montan waxes were not identified by Statistics Canada.

10.6 CARBON BLACK

1061 CARBON BLACK PRODUCTION

There are three carbon black producers; Cabot Carbon and Columbia Chemicals located in Ontario and Cancarb in Alberta. The 1982 production of 110 kilotonnes was approximately 61 per cent of stated capacity. Production figures for the last several years are tabulated below.

Carbon Black Production in Kilotonnes

1979	1980	1981	1982
144	124.5	127.5	110.5

SOURCE: /4/.

The two Ontario plants produce furnace black but the Calgary plant produces thermal black. (See section 413 for definitions of thermal and furnace blacks).

1062 CARBON BLACK CONSUMPTION

Over 95 per cent of carbon black is consumed by the rubber industry, primarily for the manufacture of tires. The remainder is consumed in the ink, paint and plastic pigment industries. The rapid decline in demand from 1979 to 1982 was a direct result of the slow

down in the North American automoble industry. This trend can be seen in Table 10-15 below.

TABLE 10-15

Consumption of Carbon Black

Industry	Quantity in Kilotonnes 1979	1980	1981	1982
Rubber Compounding	130.0	110.0	112.0	95.0
Printing Typewriting Inks	2.5	2.5	2.5	2.5
Paint Pigment	0.7	0.7	0.6	0.6
Plastic Pigment	1.5	1.5	1.4	1.3
Miscellaneous	0.5	0.5	0.5	0.5
TOTAL	135.2	115.2	117	99.9

SOURCE: /4/.

10.7 SUMMARY

Coal coke production in Canada is limited to the four integrated steel producers which appear to consume most of the production in their own blast furnaces. In 1980, 87% the coal carbonized in Canada was imported from the United States. Imports of coal coke, especially foundry coke, and petroleum coke appear to have supplied most of the non-blast furnace consumption.

In 1981, the Canadian non-blast furnace consumption in kilotonnes was:

Iron mines	118.2
Smelting and refining	84.5
Ferro alloy	82.6
Steel furnaces	35.3
Foundry	63.1
Industrial chemicals	155.3
Petroleum coke	848.5

Canada has several ferro-alloy producers centered in Quebec and, to a limited extent, Ontario. The literature survey indicated that these are the highest potential peat coke users (see Section 7.4).

There is only one manufacturer of activated carbons in Canada, with imports supplying the major portion of Canadian activated carbon demand. Demand appears to have stabilized at just over 5 kilotonnes, worth $8.4 million in 1982. Consumption is evenly distributed among industries, except for the cane and beet sugar producers which accounted for 46 percent of the market in 1982.

The use of coal tars appears well distributed across Canada. Total 1980 coal tar and pitch shipments were worth $58 million.

Imports of carnauba waxes were worth $373,000 in 1983, averaging $2.61/kg. The value of montan wax imports decreased from $727,000 in 1980 to $481,000 in 1983. China exported Montan waxes to Canada in 1983. Consumption of these waxes is not identified by statistics Canada.

Canada has three carbon black producers which manufactured 110.5 kilotonnes in 1982. Over 95 percent of this production was consumed by the rubber industry.

PART 11

POTENTIAL DEMAND FOR PEAT PRODUCTS IN CANADA

11.1 INTRODUCTION

Before potential demand for carbonized peat products can be estimated, it is necessary to define "potential". Three factors have to be considered: future economic and social environments; time frames of realization; and the probability of realization.

For purposes of this analysis, it is assumed that the economic recovery will continue, and that business confidence will improve. This is an assumption and does not imply that these conditions are forecast by Monenco, since an in-depth analysis has not been part of this study.

As production of peat coke and tars would start 6 years after the peat sod development begins (see Section 9.2), the time frame of realization should extend beyond 6 years. However, forecasting consumption patterns for this time horizon involves many factors beyond the scope of this investigation. Therefore, estimates will indicate the quantities of each product that could be consumed, given 1980 pre-recessionary consumption levels, and appropriate capital subsidies to lower the price of peat coke to compete with current prices of industrial grades of coal coke (see Tables 9-4 and 9-5).

The last item is the probability of realization. This will not be specified for two reasons. First, the products would be replacing or competing with well established products and suppliers. Thus the estimate includes uses that Monenco feels users would consider and possibly evaluate but not necessarily implement within the next five years. Secondly, some products (i.e. activated carbons) are finding new uses, and these are difficult to anticipate.

It is concluded that the potential demand should be defined as that which could develop assuming consumption patterns return to 1980 levels, in applications that are technically feasible and where a willingness to test the products has been indicated.

11.2 SURVEY METHODOLOGY

The objective of the survey was to determine:

- the feedstock specifications of current carbon product users identified in Section 10;
- limitations, if any, imposed by current processes;
- approximate quantities consumed;
- levels of awareness of peat carbon products and their applications;
- whether users would test peat carbon products in their processes.

A mail survey was used to contact coke, activated carbon and tar users. A telephone follow-up was used in those areas where a low response to the mail questionnaire was encountered. The mail survey allowed contact with a potentially larger user group at a lower cost than would have been possible through personal visits. At the same time, the survey could be extended to include users across Canada.

A telephone survey, limited to Ontario and Quebec, was used to contact wax users. No questionnaire was developed as there was a lack of statistical information (see Section 1053) on the consumers and limited technical information on peat waxes (see Section 5.2).

1121 QUESTIONNAIRE DEVELOPMENT

Separate coke, tar and activated carbon users were visited in the Toronto area. The coke user and tar user were given a peat product description (see Appendix C1 and C2) and the areas of interest identified in Section 11.2 were discussed. A prototype questionnaire was developed based on these interviews.

This questionnaire was evaluated by further visits to additional coke and activated carbon users and an additional tar user. The finished questionnaires were then distributed to users identified in Section 10.

The results of this survey should not be taken as statistically significant as they comprise a spot sample. The following sections present summaries of the coke, activated carbon, tar and wax market surveys.

11.3 PEAT COKE SURVEY RESULTS

Thirty six questionnaires (see Appendix C1) were distributed to potential peat coke users and 15 current coke users replied. This information was included with the data obtained during questionnaire development (see Section 1121). The data obtained was grouped into three categories: chemical producers; producers of ferro-alloys, iron castings, and steel; and mining, smelting, refining, and iron ore pelletizing. Highlights of the responses are tabulated in Table 11-1.

The identified consumption of coal coke was between 280,000 to 530,000 tonnes. This accounts from 50 to 90 per cent of the 1982 consumption for non blast furnace coke (see Tables 10-3 and 10-4).

TABLE 11-1

Peat Coke Survey Summary[1]

	Categories		
	Chemical Producers	Iron and Ferro Alloys	Mining, Smelting and Refining
Identified Consumption of Coal Coke (kilotonnes)	150-250	44-94	85-190
% imported	100	50	100
Identified Consumption of Petroleum Coke (kilotonnnes)	-	2-10	25-50
% imported	-	100	100
Use of Coke:[1]			
Carbon Source		77%	27%
Reducing Agent	100%	30%	73%
Heat Source		30%	64%
Willing to Test	100%	50%	82%[3]
% not Willing to Test	-	5%	18%
% Need More Information		45%	-
Existing Knowledge	medium[2]	low	low

NOTES: 1) Percentages are calculated as a percentage of total volume used. Groups can add up to more than 100 due to multiple choices.
2) One user had tried peat coke on an experimental basis.
3) One lead blast furnace operator was willing to test peat coke, even though peat coke does not appear to be suited to this application.

These were 12 requests for additional information on peat coke as compared to 3 requests for further information about activated carbons and 1 request about peat tars. This would indicate more interest in peat coke than in the other carbonized products as approximately the same number of questionnaires was distributed to each group (15 coke, 12 activated carbons, and 2 tar questionnaires were returned identifying current users). The interest can perhaps be explained by the existing lack of knowledge about peat coke claimed by most respondents, but, more importantly, that coke usage in many operations is a large enough percentage of the raw material input that users want to be kept informed of potential alternate sources and cost savings. Of interest was the fact that two coke users had tried samples of peat coke within the last ten years on an experimental basis.

1131 CHEMICAL PRODUCERS

Identified consumption of coke in the chemical industry accounted for 100 percent of this industry's coke usage (see Table 10-7) with all coke being imported from the USA.

The coke being used appears to be a screened by-product from blast furnace coke, and the smaller sizes (less than 25mm) predominate.

Coke fines, generally less than 5mm, appear to be undesirable. All the coke was reported to be imported.

Coke is generally used in electric furnaces as a reducing agent. One producer is quite familiar with peat coke and feels that the high reactivity and the resistance characteristics offer processing advantages.

1132 IRON, STEEL AND FERRO ALLOYS

This category includes foundries, steel mills and ferro alloy producers. The users include both cupola and electric furnace operators. Fifty percent of the coal coke and all the petroleum coke identified in this survey is imported from the U.S.

One of the four integrated steel mills, a blast furnace operator, was surveyed. This questionnaire is not included in Table 10.2.1. The responses confirmed that peat coke is not suitable for blast furnaces, as was indicated in the literature survey (see Table 7-5 and Section 741).

With few exceptions, foundry and steel mill usage is well distributed with individual consumptions of less than 2,000 tonnes common. Steel electric furnace operators use coke breeze and petroleum coke as a carbon raiser. Price is considered the most important specification.

Between 20 and 35 percent of the potential foundry coke market (see Table 10-10) was identified by this survey. As indicated in the literature survey this group requires low sulphur content (less than 0.6%) with large sizes specified (one user specified 4" x 6"). Generally the effects of high reactivity on the process are not known, although high resistivity is thought to have little effect on the process. There is a lack of willingness to test peat coke before additional information is required.

The ferro alloy producers surveyed accounted for 35 to 60 per cent of the 1981 consumption noted in Table 10-4. This group use both coal cokes and petroleum cokes as well as charcoals and in some cases woodchips. The literature survey indicated that this group should have the highest potential for peat coke use (see Section 742), however, the survey showed mixed results. One company has tested samples of peat char produced in the early 1970's. This producer

showed great interest, being familiar with the advantages, lower coke and electricity consumption, of using peat coke. Another ferro-alloy manufacturer specified low phosphorus (0.02% max), minimum fixed carbon of 85%, and maximum contents of 10% ash, 0.75% sulphur and 4% volatile matter. Careful raw peat selection would be required to match the phosphorus specification (see Section 723), although the remaining specifications can be met with European peat feedstocks. Again this producer believes that the high reactivity and resistivity offers processing advantages. Another operator, using petroleum coke, identified a maximum ash content of 0.7% as the most important specification (O.R.F. samples had ash ranging from 5%-15%). This would exclude peat coke use in this application. All other requirements could be met according to published European peat coke characteristics. An abrasive manufacturer indicated a lack of interest as his coke consumption is a very low percentage of total raw material input. It appears that any change in coke type would require a significant amount of testing in order that the currently unknown benefits and potential adverse effects on the process could be identified.

It is significant to note that all those replying are willing to test peat coke, except the abrasive manufacturer which would require more information before deciding on a test run.

1133 MINING, SMELTING AND REFINING

This group uses both coal and petroleum coke which were imported from the U.S. The lead blast furnace operators contacted in this survey, accounted for over 80% of coal coke consumed in the smelting and refining industry (see Table 10-3). Peat coke is not used by this group as the lead blast furnace imposes similar constraints on the coke feedstock as iron blast furnaces, namely high crushing strength and low reactivity.

An iron ore pelletizing operator, currently using a petroleum coke and coke breeze mixture, specified a maximum silica (SiO_2) content of 5%. As silica can account for a high percentage of the peat coke ash, careful peat selection would be required. However, the operator indicated that cost is the primary concern and would not be willing to pay current coal coke prices.

Those using electric furnaces for the reduction of ores and slags are presently using petroleum cokes. All rated the fixed carbon and coke size as important (90% min. and 4 mesh or less respectively). One operator emphasized that: "low sulphur (less than 1%) cokes are scarce in North America" and rated low sulphur as the most important specification. One operator thought that the high reactivity offered operating advantages as the carbon would dissolve faster. No respondent considered that the resistance characteristics of peat offered any operating advantages.

One operator has already tested peat coke samples noting that the high reactivity and low sulphur characteristics could improve processing economics.

Union Carbide, an anode manufacturer, was contacted and asked to comment on the suitability of peat cokes as a replacement for the cokes used in the production of anodes, given the information included in the peat coke survey (see Appendix C and Table 2-10). It was stated that peat coke is considered unsuitable for this application.

11.4 ACTIVATED CARBON SURVEY RESULTS

Forty questionnaires (see Appendix C2) were mailed to current activated carbon users and 12 responses were received. The data obtained were combined with the pre-questionnaire survey data (see

Section 1121) and then grouped into three categories: beverage manufacturers, sugar processors, and others. Highlights of the collected data are tabulated in Table 11-2: Activated Carbon Survey Summary.

The survey identified between 500 to 700 tonnes of activated carbon usage or 10 to 14% of the estimated 5,100 tonnes activated carbon market in Canada (see Section 1023). The cane and sugar beet processor group was most interested in receiving additional information. This interest is no doubt a result of the high activated carbon consumption represented by this group.

1141 BEVERAGE MANUFACTURERS

This group includes breweries, wineries, distilleries and other beverage manufacturers. Individual consumption is generally quite low with over 50% of those surveyed using less than 1,000 kg per year.

Most of those replying (93%) use liquid phase adsorbent carbons with only the breweries using gas phase adsorbent carbons to remove CO_2 gas contaminants. Only one activated carbon user reactivates spent material within the plant. This involves carbon used as a gas phase adsorbent.

The large number of different fluids that are filtered probably account for the range of activated carbon feedstock types. There was a large proportion of respondents who do not know the feedstock grade and thus rely on the manufacturer to specify suitable material.

The contaminants removed are generally taste and odours (i.e. chlorines, esters, phenols, etc.), and in some applications, colours. Some user specifications appear hard to quantify with one respondent using activated carbons to: "smooth and mellow spirits". In these cases the grade used is determined through testing.

TABLE 11-2

Activated Carbon Survey Summary

	Beverage	Sugar	Others
Feedstock Of Activated Carbon Used:[1]			
Coal	7%	100%	100%
Charcoal	15%	-	-
Saw Dust	1%	-	-
Don't Know	77%	-	-
Type of Activated Carbon Used:[1]			
Powdered	11%	1%	-
Granular	89%	99%	88%
Extruded	-	-	12%
Carbon Used As:[1]			
Liquid Phase Absorbant	93%	100%	88%
Gas Phase Absorbant	7%	-	12%
% Reactivated[1] in Plant	.5%	100%	52%
Quantity (tonnes)	150-214	>227	125-240

NOTES: 1) As a percent of total consumption in group.

Only two respondents identified special restrictions. One identified a minimum mesh size and the other stated that: "the carbon cannot leave off-flavours".

One carbon user described his selection process as follows:

- all activated carbon manufacturers were contacted and asked to submit carbon samples for testing;

- all carbons were tested, with some carbons proving to be too effective (removed taste as well as colour) and others having low colour removal efficiencies;
- selection was then made.

In this process, no consideration was given to the activated carbon raw material as this was not felt to be important.

1142 SUGAR MANUFACTURERS

Most of those surveyed used animal bone char exclusively or in combination with granular activated carbons. One user consumes more than 100 tonnes per year, although the exact amount was not stated.

Bone char is used to remove ash content of raw sugar. Apparently activated carbons are ineffective in ash removal, whereas bone char has colour removal as well as ash removal capabilities. Bone char is not produced commercially, the sugar processors manufactured this form of activated carbon themselves.

Individual quantities depend on the percentage of activated carbon to bone char, and degree of carbon degradation resulting from the handling and usage imposed by the process. All manufacturers re-activate the carbons in-house.

Mixing carbons with bone char imposes a unique set of constraints on the carbon characteristics. The carbon size must be consistent so that it will mix homogeneously with the animal bone char. The activated carbon must have good hardness to withstand the abrasion imposed by the filtration, screening, conveying and handling process. The temperatures used to re-activate bone char are generally lower than those used to re-activate the carbons. Since the material is not generally separated for re-activation, the lower temperatures

used to prevent complete combustion of the animal bone char must still provide effective re-activation of the activated carbon.

The activated carbon is used to remove colour from the refined sugar. For some very high grade sugars (extremely white grades) an additional purification process using powdered carbons is used.

1143 OTHERS

This group includes chemical manufacturers, rotogravure engravers, and textile manufacturers. Consumption ranges from less than 1 tonne to just under 100 tonnes average per year. Applications include purifying solutions, recovering process solvents, groundwater purification, dye recovery and gas processing.

In gas processing, non-liquid phase adsorbents are used (in the form of extruded activated carbon) to remove sulphur from natural gas. The remaining group consumes granular carbons in liquid phase adsorption processes. One large user indicated that re-activation of the carbons is not done presently.

No respondent specified any special restriction imposed by the process, with all using coal-based carbons. One of the group has recently changed carbon supplier based on obtaining "an equivalent grade at a reduced price". The user described the brand name of his previous carbon to various suppliers, and requested equivalent alternatives. Selection was based on manufacturer guarantees and lowest prices.

The Province of Ontario is currently designing a test plant to treat drinking water with granular activated carbon. No other large scale water treatment users were discovered.

The Canadian activated carbon manufacturer would like to test peat coke for suitability in his process. The current production capacity of this plant is approximately 450 tonnes per year.

11.5 PEAT TAR SURVEY RESULTS

The literature survey revealed little information about the components of peat tar. A brief description was included in the survey questionnaire (see Appendix C3) and distributed to 29 processors selected from the industries identified in Section 10.4.2. The very low response rate (2 replies) dictated a telephone follow-up. The results of this telephone survey are summarized below.

The Canadian producers of coal tar, the coal coking plants, remove the lighter fractions; Benzene, Toluene and Xylenes, and then ship the remaining material to a few reprocessors. Four reprocessors were identified, two Canadian and two American. The Canadian coal tar reprocessors are Domtar Inc. of Montreal, Quebec, and Currie Products Limited of Hamilton, Ontario. These two reprocessors produce a range of coal tar based products which include:

- Napthalenes (crude)
- Creosote oil
- Aromatic oil
- Electrode pitch
- roofing pitch
- driveway sealants
- paint and waterproofing compounds.

The recent cutbacks in the steel industry have resulted in a reduction of the supply of coal tars and consequent shortages. One of the coal tar reprocessors claimed that his production was limited by feedstock supply and not by product demand.

Coal tar is purchased for its aromatic components. Thus the coal tar reprocessors do not think that peat tars can be used for their current product lines due to their non-aromatic characteristics. One respondent stated that if aliphatic fractions were required (apparently peat tars are highly aliphatic) petroleum tars would be used. If in some cases, peat tars did contain aromatic fractions they may not be suitable for use in some situations, i.e. creosotes, as these are specified by the American Wood Preserves Association to be distilled from coal based tars. A small user of imported coal tar uses this feedstock to prepare an anti-bacterial agent. This user stressed that it is the aromatic components that are desired and that aliphatic material would not be suitable.

Some coal tar users are willing to analyze peat tars in their laboratories in order to see if other products can be extracted. Other respondents require additional information before deciding.

The users of petroleum-based asphalts all specified standard industrial classifications and grades. These specify limits on softening temperatures, sample penetration, viscosity ranges, etc. All surveyed are buying products from the petroleum refineries. None are willing to test peat tars, unless they are reprocessed to correspond to characteristics of existing feedstock. All require additional information on the properties and characteristics of peat tars to see if they could be used for production of alternative products, before further consideration.

11.6 PEAT WAX SURVEY RESULTS

The literature survey revealed little information on the uses of peat waxes except that they can replace montan and carnauba waxes. The possible uses of these waxes are quite widespread (see Section

5.2) and not identified in Canada (see Section 10.5). A telephone survey was conducted (see Table 11-3 for a list of those contacted) to determine potential interest in these waxes.

Distributors of German and American montan waxes and Brazilian carnauba waxes were contacted. None of them were familiar with peat waxes. The carnauba wax distributor claimed supply restrictions, whereas the montan wax distributors have no supply shortages. The market breakdown for these waxes is shown in Table 11-4.

TABLE 11-3

Summary of Number of Firms Contacted in Telephone Survey

Categories	Number Contacted
Wax Importers & Distributors:	3
Wax Formulators:	2
Floor Polishes Manufacturer:	5
Wood Polishes Manufacturer:	4
Shoe Polishes Manufacturer:	2
Carbon Paper Manufacturer:	2
Plastic Formulator	1

Peat waxes, due to their dark colour, would have to be used in applications where clear waxes are not demanded. The use of these waxes in the food industry would depend on approval by the various regulatory agencies. Therefore, the areas that were investigated were carbon paper, dark polishes and plastic markets.

TABLE 11-4

Approximate Market Distribution of Montan and Canauba Waxes

German Montan		USA Montan		Carnauba	
Market %	Industry	Market %	Industry	Market %	Industry
60	Plastic Formulation	large	carbon paper	90	polish
30	Shoe Polishes Car Polishes	small	polishes	10	food
10	Cosmetics Carbon Paper				

The floor polish manufacturers are all producing waxes using synthetic formulations. The use of mineral and natural waxes has largely disappeared with one manufacturer anticipating that his one natural wax product has only three years of market life remaining before demand ceases.

The wood polish manufacturers place a premium on colourless waxes. Many of their formulations are blended using a variety of feedstocks. Again synthetic waxes are gaining ground as they offer significant reductions in labour and offer more durable surfaces. Carnauba waxes are used by one manufacturer in making a paste wax, but demand for this product is expected to cease within 5 years.

The shoe polish manufacturers are using or have recently been using both montan and carnauba waxes. The waxes are blended together to produce a paste wax that meets a very narrow range of properties. One of those contacted has a foreign parent which need to approve the use of peat wax in the formulation. The other manufacturer is no

longer formulating paste waxes and consequently no longer using montan waxes. This manufacturer now produces a shoe polish kit that eliminates much of the manual labour associated with traditional shoe polish applications.

The carbon paper manufacturers use the U.S. Montan waxes because of the high oil retention properties of these waxes. Both manufacturers have foreign parent companies who specify the wax characteristics. Peat wax usage would have to be tested and approved by these parents before the subsidiaries could change their current formulations.

The plastic formulator contacted does not use wax. No further information was obtained.

11.7 SUMMARY

Fifteen coke users and twelve activated carbon users provided data in response to the questionnaires. These data were combined with the information obtained in plant visits. The response to peat tar questionnaires was low requiring a telephone follow-up survey in order to obtain any useful information. A telephone survey was also used to contact wax consumers. The results of this survey are not statistically significant but should be interpreted as a spot example.

The data obtained from the peat coke survey was grouped into three categories: chemical producers; iron and ferro-alloys; and mining, smelting and refining.

Two respondents have tested samples of peat coke within the last ten years. Both continue to show high interest in peat coke.

The survey confirmed that peat coke is not suitable for steel blast furnaces application. Use in lead blast furnaces is also limited by the high reactivity and low strength of peat coke.

The applications where coke is used as a reducing agent in electric furnaces would benefit from peat coke characteristics. Careful peat selection may be required to meet a phosphorus specification (0.02% max). Peat coke could not meet one specification for ash content (0.7% max). The estimated potential market is summarized below:

	%[1]	Tonnes[2]
Chemical Producers	100	180,000
Ferro Alloys and Steel	30	105,000
Mining, Smelting and Refining	20[3]	15,000[4]
TOTAL		300,000

1. % refer to those using coke as a reducing agent (see Table 11.1) in electric furnaces.
2. Tonnes = % x 1980 consumption by the industry from Table 10-3 through 10-5.
3. Excludes 80% consumption in lead blast furnaces.
4. Based on 1981 consumption, see Table 10-3.

Six percent of the coal coke was sourced in Canada. The rest of the coal and petroleum cokes were imported from the U.S. Many of those surveyed are willing to test peat coke. Some, i.e., lead blast furnace operator, could not use peat coke due to physical limitations. The positive response is probably due to the low levels of awareness of peat coke and the large quantities of coke currently consumed.

Unless costs of peat coke production are reduced, the potential market would disappear (see Section 9.4). Even at coal coke prices, peat coke is too expensive for iron ore pelletizing and steel electric furnace operators.

The only activated carbon users interested in receiving further information are the sugar processors. They currently use coal based activated carbons, generally mixed with bone char. This imposes special re-activation and operating restrictions. Most of the other users rely on current activated carbon manufacturers to supply suitable activated carbon grades.

Peat tar demand would depend on further identification of peat tar components. Both Canadian re-processors of coal tars are willing to test peat tars in their laboratories, however, use in their current product lines is not considered feasible as the aliphatic nature of peat tars is not suitable.

Users of montan and carnauba waxes in the carbon paper and dark polish industries would depend on foreign parent approval for Canadian subsidiary use. Use of montan and carnauba waxes in some polishes is decreasing as synthetic waxes gain acceptance. More information about peat waxes is required before potential users are able to indicate further interest.

PART 12

THE UNITED STATES AS A POTENTIAL MARKET FOR PEAT COKE AND ACTIVATED CARBON

12.1 INTRODUCTION

Current and future production, imports, exports and consumption levels of cokes are evaluated as they apply to the United States. The activated carbon market, in particular the treatment of drinking water, are highlighted.

12.2 COKE PRODUCTION

The production of coke in the U.S. has been decreasing steadily since 1970. This has been exacerbated by the recent recession and the uncompetitive condition of the U.S. steel industry. /1/2/

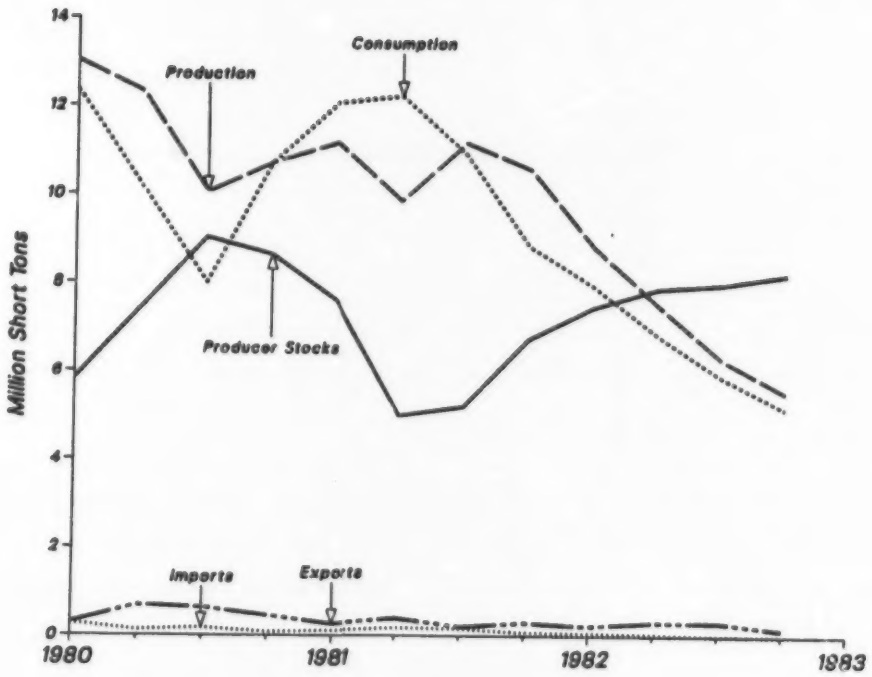
It appears that the recent upturn in steel demand has brought to an end the downward trend in coke demand (see Figure 12-1). However, high coke inventories have supplied most of the demand. By the end of the first quarter of 1983 there were 38 coke plants in operation, a reduction of 17 from the beginning of 1982./3/ The steel industry is still characterized by overcapacity, and future capacity reductions appear to be more than likely.

1221 COKE EXPORTS AND IMPORTS

The U.S.A. is a net exporter of coke. In 1982 the exports totalled 993,000 short tonnes./3/ Due to the excess capacity and oversupply of coke in the U.S.A., imports have been virtually eliminated. In 1982 the U.S.A. imported 11,000 short tonnes versus 3,974,000 short tonnes in 1979.

FIGURE 12-1

Coke Production, Imports, Consumption, Exports and Stocks



Source: /3/.

1222 COKE DISTRIBUTION

Of the coke distributed in 1982, 22.7 million short tonnes (84.6 percent) were used by the producing companies and 4.1 million short tons sold commercially. During 1982 the average price of cokes to industrial users decreased by almost 11% while blast furnace coke prices remained at 1981 price levels./4/

The 1981 and 1982 quantities of coke distributed are shown in Table 12-1. In 1982, excluding the blast furnaces, foundry coke and estimated lead blast furnace coke[1], there is a total potential market for peat coke of approximately 1 million short tonnes[2].

TABLE 12-1

Coke Distribution from Coke Plants in 1982
Quantity in Thousands of Short Tonnes

Distribution	1982	1981
Used By:		
Blast Furnaces	24,160	41,702
Foundries	1,140	1,942
Other Industrial Plants	1,224	1,148
Coke Total	26,792	44,792

SOURCE: /3/.

1 Monenco estimate:
- U.S. lead production/Canadian lead production x Canadian lead coke usage = 200,000 short tonnes.
- lead production from /5/.

2 Includes coke sales for residential heating.

12.3 PROJECTION FOR COKE USAGE

Projections for the consumption of coke must take into account the following factors:

- Possible changes in the structure of the iron and steel industry, i.e., growth of mini steel mills which purchase raw materials and the greater use of electric furnaces.
- Recent declines in coke oven capacity. The average age of 19.1 years for coke ovens indicate that further capacity reductions, due to retirement of old ovens, are likely./6/ This might create coke shortages.
- Technological improvements which decrease the amount of coke required to produce pig iron in blast furnaces.
- The supply and demand of petroleum cokes.

Although petroleum cokes are not used to a great extent by American metallurgical coal users, their acceptance by European and Japanese consumers indicate that if coal coke shortages do occur, petroleum cokes have a good substitution potential in non-blast furnace uses./7/ Supply of petroleum cokes depend on the level of activity in the aluminum industry. If the recovery of the aluminum industry does not materialize then greater quantities of petroleum coke will become available in the metallurgical markets.

In 1982, 40.9 million short tonnes of coal were carbonized at U.S. coal plants down significantly from the 61 million short tonnes in 1981./3/ Two projections for the consumption of metallurgical coal in the U.S.A. are shown in Table 12-2. They both indicate that by 1985 consumption should return to the pre-1980 levels. The more optimistic forecast indicates a 1.73 percent growth until the year 2000 with the pessimistic forecast indicating a negative growth to 1990 of 0.85% per year and a positive growth of 5% annually thereafter.

TABLE 12-2

Potential U.S.A. Metallurgical Coal Consumption
Quantity in million short tonnes

	1985	1990	2000
Source /8/[1]	85	90	110
Source /9/	71	68	87[2]

NOTES:
1) Figures are for high growth assumptions.
2) Canadian consumption of 9 million short tonnes, (assumed for the year 2,000) deducted from 96 million short tonnes N. American figure.

12.4 ACTIVATED CARBON

Industry sources estimate that current activated carbon producers are operating at less than 70 percent capacity with large inventories of activated carbons. One industry source estimates stockpiles of nearly 15 thousand tonnes of activated carbons (approximately 3 years of Canadian consumption or 2 months of current estimated U.S. production).

Treatment of drinking water is the largest potential growth area for activated carbons. Current legislation regarding the use of activated carbon is still the subject of controversy between the U.S. Environmental Protection Agency (EPA) and the water resource utilities. Until the relevant issues are resolved, it is unlikely that activated carbon usage will increase in this area./10/

More traditional areas of activated carbon use will depend on several factors:

- the rate of economic growth;
- the rate of contamination of the environment; and
- political processes affecting legislation.

The substitution potential for peat coke as an activated carbon feedstock depends on several factors that remain unclear at this time:

- that activated carbons from peat coke exhibit better characteristics than carbons from alternate feedstocks;
- and that peat coke can be used in processes employing other feedstocks.

12.5 SUMMARY

Due to reduced capacity utilization in the U.S., 1982 coke imports were virtually eliminated. The total potential peat coke market based on 1982 consumption data is approximately 1 million short tons, one coal forecast indicates an average annual growth of almost 1.75% until the year 2000. However, another forecast indicates negative growth to the year 1990.

Use of activated carbon for water treatment, a promising market, depends on the resolution of conflict between the E.P.A. and water resource industries. Until this is achieved, current overcapacity may remain.

PART 13

OTHER GEOGRAPHICAL AREAS AS POTENTIAL MARKETS FOR PEAT COKE

13.1 INTRODUCTION

Current and forecasted coke consumption for Western Europe and Latin America, (both groups include Nations classified in Section 2.2, Table 2-4, as coal coke importing nations) are presented in this part. Consumption of coal coke in Finland is highlighted. Finland exports the majority of peat coke even though it is totally reliant on imports for metallurgic cokes. Although Japan is classified as a coal coke exporting nation (see Section 2.2, Table 2-2), coke consumption forecasts are presented as Japan imports coking coal from Canada and is largely reliant on coal imports.

13.2 WESTERN EUROPE

The EEC steel cartel is beginning to achieve capacity reductions in steel manufacturing which total 27 million tonnes. Italy is eliminating 5 million tonnes of actual capacity./3/ The U.K. is attempting to reduce capacity by 25 percent from 1980 production levels./3/ France is cutting its subsidies to the steel industry by two thirds of the 1982 level./3/

Steel production by electric arc furnace is anticipated to increase at an average rate of 3% per year from 1979 to 1985. The remaining production processes will experience negative annual growth rates with /4/:

basic oxygen furnace	- 0.1%
open hearth and other furnaces	- 40.2%
iron foundry castings production	- 0.4%

1321 COKE CONSUMPTION

Coke production in Europe was 60 million tonnes in 1982 distributed 56% to the integrated steel makers and 44% to independent coke manufacturers./5/ Forty-six million tonnes were consumed by the iron and steel industry, stock levels increased by 3.8 million tonnes, and the remaining 10 million tonnes went for other purposes in 1982./5/

Projections for 1985 indicate that blast furnace consumption will grow to approximately 50 million tonnes and other uses will grow to 18-20 million tonnes./6/ At this time, demand will equal current capacity, however, lower capital investments in coke production facilities could indicate that the current capacity is becoming increasingly obsolete. Therefore shortages may well occur./6/ On the other hand, the increased supply of U.S. petroleum cokes may meet any metallurgic coal shortages or at least provide relief for market demand.

1322 FINLAND

Finland, identified in Section 2 as a coke importion nation, is totally reliant on coke imports./12/

Consumption of coal coke has increased at an annual average of 4% from 1976 to 1980. Consumption in these years has shown wide swings. The iron and steel industry accounted for approximately 61% of consumption in 1980 and 17% in 1978; gas producers on the other hand, accounted for 83% of consumption in 1978 and 39% in 1980. Local consumption of peat coke is limited to barbecuing, the remainder being exported (see Section 821).

TABLE 13-1

Finland Consumption of Coke

Year	Primary Iron & Steel	Chemical Industry	Other Industry	Residential, Commercial, Farm	Used for Gas Production	Total
1976	565	1	40	17	284	907
1977	537	0	40	16	350	948
1978	164	0	0	2	822	988
1979	216	0	0	4	880	1,100
1980	640	0	0	12	409	1,061

SOURCE: Dialog File 84: PTS International Time Series - 1983/ANL, Finland.

13.3 JAPAN

The Ministry of International Trade and Industry started rationalizing Japanese production in 1978. This process is still continuing with an announcement in July 1983 that electric steel production was to be cut by 4 million tonnes./7/ Nippon Steel, the world's largest steel company has announced that it is reducing its capacity to 36 million tonnes (1978 capacity 46 million tonnes)./2/

Imports account for all coking raw material in Japan. The Japanese requirement for coking coal was the prime mover in development of Western Canada coal fields and absorbed 46% of Alberta coal production in 1981./9/ As Japan is reliant on foreign energy resources it is anticipated that coal imports will rise to replace the reliance on petroleum. The amount of imported metallurgic coal is forecasted to increase to between 80 and 84 million tonnes in 1985 from 69 million tonnes used in 1977./10/ However, petroleum coke may absorb much of the short term increase. In the long term, there may

be an opportunity to use peat coke in specialized niches, given the existing rationalization of the integrated mills who coke coals and the growth of mini-steel mills which would purchase coke.

13.4 LATIN AMERICA

Latin America is experiencing an increase in the demand for steel. To meet this increase, domestic capacity is being increased./10/ This requirement is being met by the increased use of electric furnaces and direct reduction furnaces. The capital requirement for a new electric steel mill using scrap as feedstock is only about 50% of that required for new integrated works. If direct reduction furnaces supplies the raw material the capital cost is about 60% of the equivalent integrated plant./1/ Direct reduction plants in South America have been supplying European and Japanese markets with sponge iron./2/

The projection of growth in Latin America by furnace type is given in Table 13-2.

To meet this growing steel demand, Latin America will be a net importer of metallurgic coal and coke. The three countries, Colombia, Mexico and Brazil will account for 94% of the projected 1985 consumption with Brazil alone accounting for 40%. Table 13-3 presents estimates of metallurgic coal demand in these countries.

Mexico imports coking coal from Canada, the U.S., and Australia. A significant portion of Mexico's steel industry requirements are imported directly as coke./10/

The Brazil national steel production expansion plan will require 30% of metallurgic coal consumption to be supplied by

TABLE 13-2

Latin America Production of Crude Steel
Quantity in million tonnes

Furnace Type	1979	1985	Annual Average Growth Rate
Basic Oxygen	13.2	28.3	13.5%
Electric Arc Furnace	9.1	18.0	12.0%
Open Hearth & Other Furnace	4.8	3.9	-3.5%
Iron Foundry Castings	2.6	4.4	9.2%
TOTAL	29.7	54.6	10.7%[1]

NOTE: 1) Weighted average percent growth.

SOURCE: /11/.

TABLE 13-3

Coal Production, Use, Import, and Export Projections
for Metallurgic Coal Demand. Million Metric Tonnes
Quantity in million tonnes

	Colombia		Mexico		Brazil	
	1980	1985	1980	1985	1980	1985
Production	8.5	15.5	4.3	6.1	1.6	3.6
Consumption	5.3	6.9	6.9	9.8	6.6	15.0
Export	3.2	8.6	-	-	-	-
Import	-	-	2.6	3.7	5.0	11.4

SOURCE: /10/.

indigenous coals. Brazil and Poland have a trade agreement whereby Polish imports will grow to 10 million tonnes./10/ This will leave an estimated 1.4 million tonnes of coal demand still to be supplied.

13.5 SUMMARY

The E.E.C. steel cartel is reducing steel capacity. However, the use of coke in non-blast furnace applications is forecast to increase from 10 million tonnes in 1982 to 18-20 million tonnes in 1985. Coke shortages may occur because of obsolete coking facilities. Despite Japan's capacity reductions, Japan's metallurgic coal imports are forecast to increase to 80-84 million tonnes in 1985 from the 69 million tonnes consumed in 1977.

The highest potential growth area is Latin America where crude steel production is estimated to grow by nearly 11% annually from 1979-1985. Much of this growth will be through use of electric and direct reduction furnaces. Coke use is centered in Brazil, Mexico and Colombia, with these countries forecast to account for 94% of metallurgic coal consumption in 1985. Mexico and Brazil are forecasted to import over 15 million tonnes of metallurgic coals in 1985.

PART 14

CONCLUSIONS AND RECOMMENDATIONS

14.1 CONCLUSIONS

A preliminary estimate of the potential demand for peat carbon products, the result of a user survey and a literature review, has been developed and presented.

The most promising application for peat coke is as a reducing agent in electric furnaces in the chemical, ferro-alloy, mining, smelting and refining industries. High reactivity and unique electrical resistance characteristics offer process advantages. European ferro-silicon producers have obtained a 12%-15% reduction in electrical energy consumption and a 20% reduction in coke consumption by the use of peat coke. It is expected that peat coke would offer similar operating advantages to Canadian users. Lower sulphur content will become an important peak coke characteristic as low sulphur coal and petroleum cokes become scarcer.

The production of Canadian peat coke would begin as much as six years after bog development starts as up to seven years can be required to prepare a peat bog. This is dependent on weather conditions. This time horizon with its attendant uncertainties increase the difficulty of forecasting potential demand.

The cokes that peat coke would replace are by-products. Coal cokes used in electric furnaces are a screened by-product of blast furnaces and petroleum coke is a by-product of refineries. Supply of these by-products is generally insensitive to demand. Market equilibrium is maintained by price adjustment. These price variations increase the levels of uncertainty in projecting future peat coke consumption as they depend on activity in unrelated or loosely related industries. Most importantly this increases the risk of a peat coke operation as prices can drop below peat coke breakeven prices without affecting the supply of competing products.

Most of the coke used in Canada in electric furnaces is imported (94% of the coke identified in this survey originated in the U.S.). However, prices for coke in Canada appear to be loosely linked to U.S. prices as the price of industrial coke dropped 11% in the U.S. and increased 2% in Canada in 1983. These differences could be due to:

- Exchange rate fluctuations between the U.S. and Canadian dollars
- Increased transportation costs resulting from fuel price increases.
- Small tonnage users who lack purchasing power.

The price of peat coke necessary to recover capital and operating costs is much higher than the current market prices for competing fuels on a per tonne basis. Minimum capital subsidies ranging from $7 million to $22 million are required to lower capital and operating cost recovery price of peat coke to current prices of $140/tonne of U.S. industrial coal cokes sold in Canada.

Given appropriate capital subsidies, estimates of the potential peat coke markets are shown below:

	kilotonnes
Chemical producers	180
Ferro-alloys and steel	105
Mining smelting and refining	15
TOTAL	300

The approximate number of companies and their distribution for the chemical and ferro-alloy groups are:

	Chemical Producers	Ferro-Alloys
Newfoundland	1	-
Quebec	1	6
Ontario	1	7

As can be seen, Quebec and Ontario have the highest concentration of users. The chemical producers are the largest single users on a per tonne basis.

Careful peat feedstock selection is required to obtain appropriate product specifications, in particular, ash and fixed carbon content. Proximity to users would suggest that a plant and bog located in Quebec would minimize transportation costs.

From the information supplied by V.T.T. it appears that the Outokumpu Oy process has the lowest capital and operating costs per tonne of peat coke. The peat coke produced has a higher percentage of fines and smaller peat coke sizes than the peat coke obtained from the Wielandt process. These factors are felt to be unimportant as the coke fines are used to obtain energy self sufficiency and the Canadian coke size specifications are met.

The addition of a briquetting plant and a power station lower the cost recovery price of peat coke. However, if the coking plant is located close to the coke consumers, it would be in an area that already enjoys a surplus of hydroelectric power. A full evaluation of the briquette, electric and thermal power markets has not been carried out.

All foundry coke consumed in Canada is imported. At this time peat coke appears to be too reactive for use as foundry coke. No foundry coke users were willing to test peat coke without additional information.

All grades of activated carbons can be produced from peat although the high volatile content of peat increases manufacturing costs. According to VTT the properties of activated carbons from peat are very dependent on all steps in the manufacturing process.

The Canadian demand for activated carbon is estimated to be just over 5 kilotonnes, was worth $8.4 million in 1982. The market is considered mature with volumes remaining steady since 1978. The largest single segment is the sugar manufacturers who consumed 46% of this market by volume although only accounting for 17% on a dollar basis.

To determine whether the Candian market for activated carbons would support a peat based plant the following assumptions have been made.

Although V.T.T. estimated a minimum economic plant size of 1 - 1.5 kilotonnes, the following analysis has been based on the assumption that a 0.5 kolotonne plant is economic. At this production level the plant would have to capture 10% of the domestic market.

The V.T.T. estimate of minimum economic plant size (see Section 3.3) assumes using peat coke as feedstock. The use of raw peat as a feedstock would increase production costs thus increasing the minimum plant size. Peat coke is not currently available in Canada therefore the assumption of an economic plant size smaller than the Finnish plant is optimistic.

As the market is mature, a new supplier of activated carbons would have to displace existing suppliers. Market forces would suggest that this can be accomplished by offering a combination of lower prices and/or improved performance characteristics. Price competition is unlikely as the other manufacturers have large domestic plant capacities offering economies of scale. Neither the user survey nor the literature survey revealed applications where peat carbons offered measurable operating advantages. The literature survey merely indicated that peat activated carbons could match the characteristics of existing carbons.

Norit is known to manufacture peat based activated carbons. Activated carbons originating in the Netherlands had 15% of the Canadian market in 1982 (see Table 10-11). It is reasonable to assume that peat carbons have already achieved penetration in the Canadian market. Price competition would be difficult as these carbons were the lowest priced, averaging 90 cents/kg versus a national average of $1.62/kg (see Table 10-12). Therefore, although current demand exists for peat based carbons, extremely low prices may be stimulating this demand.

Finally, the activated carbon market is quite segmented. Different users require carbons with different characteristics. The largest segment, the sugar producers, pay the lowest prices for their carbons. The 0.5 kilotonne plant would have to capture 20% of this market, an unlikely prospect.

In conclusion, the Canadian market is not large enough to support a peat based activated carbon plant. Although costs were not available, the smallest economic plant in Finland is between 1 to 1.5 kilotonnes. It is unlikely that Canadian activated carbon demand of this magnitude could be developed for a new producer.

Peat waxes are possible substitutes for carnauba and montan waxes. Canada imported $373,000 of montan waxes in 1983. These markets are considered to be mature or in decline. There ae many unidentified components of peat waxes which need to be isolated before areas of application can be extended. Peat waxes cannot compete with montan waxes on a price basis and lack some of the desirable carnauba wax characteristics. At present, the recovery of peat wax cannot be justified on an economic basis.

Peat tar has many components that have to be identified. They are apparently highly aliphatic in nature unlike coal tars which are predominantly aromatic. Heating oil was the highest end value use identified for peat tar. At present the recovery of peat tar cannot be justified on an economic basis. The two Canadian coal tar re-processors would be willing to test peat tars to see if useful components can be extracted, given that a peat tar supply develops.

The manufacture of carbon black from peat is not considered technically feasible at this time.

The U.S. market potential for peat coke is a maximum of 1 million short tons. Coke prices are lower in the U.S. than Canada, therefore Canadian peat coke would be at an even greater price disadvantage. Growth in the activated carbon market would depend on resolution of conflict between Environmental Protection Agency and water resource utilities. U.S. activated carbon manufacturers are estimated to be producing at less than 70% capacity, therefore current export potential is small.

Steel capacity reductions in both Western Europe and Japan are the result of a decreased demand for steel and increased competition from low cost producers located in developing countries. Despite these capacity reductions coke consumption is forecast to increase. Obsolete coking facilities in Europe may create coke shortages thereby creating an export potential.

The highest potential growth area for metallurgic coke is Latin America, particularly Brazil, Mexico and Colombia. Crude steel production is estimated to grow by nearly 11% annually from 1979 to 1985. Mexico and Brazil are forecasted to import over 15 million tonnes of metallurgic coal in 1985, suggesting that a large export potential may develop.

14.2 RECOMMENDATIONS

1) Upgrading peat through coking is not considered practical at this time. Peat coke is too expensive when compared to alternate cokes. There are both economic and technical issues that have to be resolved before a definitive conclusion can be reached.

2) The net benefit of import substitution may justify the capital subsidies required to reduce the price of peat coke. Further economic analysis is required.

3) The use of peat coke as a substitute for foundry coke requires further investigation into the technical and economic consequences of adding another row of tuyeres to counteract the high reactivity. The high cost of foundry coke ($257/tonne in 1982) could support a peat coke operation.

4) If import substitution warrants capital subsidies then tests should be conducted with Canadian peat coke to see if the process economies experienced by European ferro-alloy producers can be duplicated. If suitable peat bogs can be located near the Quebec ferro-alloy producers, then peat coke for these tests should be produced using the Outokumpu Oy process.

5) The Canadian activated carbon market is not large enough to support activated carbon development, especially where considering the small end user segments. If uses in water treatment increase, this market should be re-evaluated.

6) Peat is a rich source of chemicals. The future value of these chemicals may exceed the present value of converting peat into coke. Given the small size and maturity of the Canadian wax market, and the small quantities of peat tars produced in a coking operation, research costs of isolating the unknown components could not be justified by present applications. However, research could open up new market opportunities.

APPENDIX A

TERMS OF REFERENCE

TERMS OF REFERENCE

INTRODUCTION

Fuel-grade, well humified peat at about 50% moisture content can be combusted using established technology. However, further processing of the peat can yield potentially higher valued materials. It may be advantageous to produce such products in their own right or in parallel with a fuel peat operation. Possible products from carbonization processes include activated carbon, metallurgical coke, carbon black and other special carbons. Peat may be a good feedstock for production of these products, depending upon both technical and economic considerations.

Some research work has been done with respect to these processes, particularly in Europe. There is, however, relatively little information available on Canadian and global requirements in relation to technical specifications, production, potential markets and costs particularly under Canadian conditions.

OBJECTIVES

The purpose of this initiative is to gain a detailed analysis of the market potential of these products from peat with an assessment of the Canadian position in such a market. The results of the study will identify processes and their associated products with potential for commercialization in Canada and highlight specific technical developments that may be required.

SCOPE

The work involves both detailed technical and economic assessments of existing and potential commercial processes for the production of carbon products from peat.

The work includes:

1. a global survey of existing commercial operations to provide information on both technical details and production costs;

2. a survey of processes under development including a technical assessment of their feasibility;

3. an analysis of Canadian and global market conditions with respect to the potential of these products for both the domestic and export markets;

4. a rating of the identified processes with respect to their economic viability in Canada, highlighting critical parameters;

5. recommendations for a research strategy designed to improve the economic feasibility of one or more of these processes in Canada.

APPENDIX B

ONTARIO RESEARCH FOUNDATION REPORT ON PEAT CHAR

Report No. PP/PSEF 84-40-20277 (Revised)

Agglomeration of Peat Char

MONENCO ONTARIO LTD.,
2 St. Clair Avenue, East,
Toronto, Ontario
M4T 2T5

J. FORMAN
A.J. LAST
H.G. BRANDSTATTER
MATERIALS DIVISION

November 7, 1984

ONTARIO RESEARCH FOUNDATION

SHERIDAN PARK RESEARCH COMMUNITY

MISSISSAUGA, ONTARIO, CANADA L5K 1B3 • (416) 822-4111 • TELEX 06-982311

WE, THE ONTARIO RESEARCH FOUNDATION, STIPULATE THAT THIS DOCUMENT IS SUBJECT TO THE FOLLOWING TERMS AND CONDITIONS:

1 ANY PROPOSAL CONTAINED HEREIN WAS PREPARED FOR THE CONSIDERATION OF THE ADDRESSEE ONLY. ITS CONTENTS MAY NOT BE USED BY NOR DISCLOSED TO ANY OTHER PARTY WITHOUT OUR PRIOR WRITTEN CONSENT.
2 ANY TESTING, INSPECTION OR INVESTIGATION PERFORMED BY US WILL BE CONDUCTED IN ACCORDANCE WITH NORMAL PROFESSIONAL STANDARDS. NEITHER WE NOR OUR EMPLOYEES SHALL BE RESPONSIBLE FOR ANY LOSS OR DAMAGE RESULTING DIRECTLY OR INDIRECTLY FROM ANY DEFAULT, ERROR OR OMISSION.
3 ANY REPORT, PROPOSAL OR QUOTATION PREPARED BY US REFERS ONLY TO THE PARTICULAR MATERIAL, INSTRUMENT OR OTHER SUBJECT REFERRED TO IN IT. NO REPRESENTATION IS MADE THAT SIMILAR ARTICLES WILL BE OF LIKE QUALITY.
4 NO REPORT ISSUED BY US SHALL BE PUBLISHED IN WHOLE OR IN PART WITHOUT OUR PRIOR WRITTEN CONSENT.
5 OUR NAME SHALL NOT BE USED IN ANY WAY IN CONNECTION WITH THE SALE, OFFER OR ADVERTISEMENT OF ANY ARTICLE, PROCESS OR SERVICE.
6 WE RESERVE THE RIGHT NOT TO COMMENCE AND/OR CONTINUE ANY WORK UNTIL PAYMENT ARRANGEMENTS SATISFACTORY TO US ARE ESTABLISHED.

1. INTRODUCTION

The work reported was conducted during January to April 1984 for Monenco Ontario Limited, Toronto, Ontario.

Exploratory agglomeration tests were carried out on a sample of raw peat as well as on a Wetox processed peat sample to determine the feasibility of producing solid fuel for the foundry industry.

The procedure used for this investigation was identical to the one adopted for briquetting coke breeze which was carried out in 1979 with ORF funds.

2. BACKGROUND

As far as metallurgical coke applications in the foundry industry are concerned, the only merchant producer of foundry coke, La Salle Coke Company, ceased operation in Montreal in 1977. Canadian foundries presently purchase coke supplies from the United States and overseas.

There are 48 foundries in Ontario which consumed 246,000 tons of coke in 1975, equivalent to some 70% of the total Canadian consumption. Similar consumptions apply to-date.

Foundry Coke sells for approximately $210/short ton coke. U.S. price is $160/ton coke at the foundry.

To obtain full benefit from coke for foundry applications, the following properties are required:

- low reactivity with respect to CO_2 to ensure maximum heat release on burning
- large size coke, up to six inch
- good strength and abrasion resistance.

The reactivity of coke can be adjusted by controlling the final carbonization temperature. Foundry coke requires low reactive carbon, so that the carbon loss due to the reaction $CO_2 + C \rightarrow 2CO$ is low. Avoidance of this loss results in a maximum amount of heat released on combustion. The more reactive metallurgical coke for blast furnace use, on the other hand, generates larger quantities of CO which is necessary for the iron oxide reduction.

A typical composition of foundry coke is as follows:

% Fixed carbon	90.0
% Volatiles	1.5
% Ash	8.0
% Sulphur	0.5
	100.0

Binder systems that have been used in formed coke development consist primarily of tar, asphalt, pitch and bitumen type materials. In addition, soft bituminous coal has been employed as binder addition.

At Ontario Research Foundation, a low cost binder system has been developed employing emulsified asphalt. Savings in manufacturing costs are envisaged due to:

- Cold blending of binder and aggregate rather than hot blending.
- Low binder consumption - binder levels of 5 wt% or less appear sufficient.
- Reduced effort due to elimination of drying and heat hardening of green briquettes.

For any given binder system, the parameters affecting strength and abrasion resistance are top size and size distribution of the aggregate, binder level, forming pressure and curing temperature.

An acceptable product needs to have sufficient green strength for handling as well as good hot compression strength to resist degradation in the hot zone of the cupola.

Briquetted coke breeze exhibited a green strength of >110 load kilograms (250 lbs). On drying at near 100°C the compressive strength increased to >450 load kilograms (1000 lbs). These initial results were quite encouraging and suggest that the green briquettes could be handled without drying. Elimination of heat curing '220-230°C) to gain high temperature strength is another cost saving feature of this procedure.

3. DESCRIPTION OF MATERIALS USED

(a) Wetox Peat Char

A total of 575 g. of Wetox char was obtained from the Environmental and Chemical Engineering Division (ECE) of ORF. The peat used for Wetox processing originated from a bog 40 miles east of Montreal, south of Highway 20 (von Post H6 and H9 in equal proportion). To improve the handling properties of this wet filter cake material, the sample was dried overnight at 110°C and then passed through a 16 mesh screen to break up the brittle coke. The residual moisture in the char amounted to 2.79%.

(b) Raw Peat

Several pounds of raw peat from Parry Sound, Ontario (von Post H6 - H8) were received from ECE. This sample was dried overnight at 120°C. Based on the weight loss, this sample contained 91.20% moisture before drying. The residual moisture amounted to 1.25%.

(c) Emulsified Asphalt

The material used was marketed as driveway sealer. From past investigations this type of emulsified asphalt contains approximately 50% water and 50% asphalt.

To improve mixing with solids at room temperature, the emulsified asphalt was diluted with an equal weight water. A small quantity of bentonite was added to improve the hot strength properties of briquettes.

The proportions of the binder mix were:

Emulsified asphalt	50%
Water	48%
Bentonite	2%

This binder mix was successfully used on previous investigations.

In this investigation additional water was added to improve penetration of the binder into the aggregate. The binder level was kept constant for all solids tested and amounted to 28 g. binder mix and 30 ml water per 100 g. of peat solids.

Based on these mix proportions a total of 7 g. of asphalt binder was used per 100 g. of peat solids, or 6.5%.

4. DESCRIPTION OF PROCEDURES USED

(a) Compaction:

A metallurgical mounting press was used for all compaction tests. The closed die had an inside diameter of 2.54 cm (1 in.). Maximum pressure was applied at $7.03 \cdot 10^6$ kg/m^2 (10,000 psi). At these pressures, most of the water added is squeezed out. The cylindrical briquettes so produced were approximately 2.54 cm (1 in.) high.

(b) Charring

The charring of dry peat was accomplished at temperatures ranging from 450 to 550°C employing a laboratory tube furnace that was flushed with nitrogen. Peat samples were charred in loose as well in compacted form.

5. PREPARATION OF BRIQUETTES AND RESULTS

The oven-dried peat from Ontario and the oven dried Wetox-processed peat from Quebec were compacted in a closed die at a pressure of $7.03 - 10^6$ kg/m^2 (10,000 psi) producing 2.54 cm (1 in.) diameter x (1 in.) 2.54 cm long cylindrical compacts for evaluation of properties such as compressive strength and drop tests to evaluate handling strengths.

The compacts made from dried Ontario peat were further processed by

- charring the compacts at 450 and 550°C
- breaking the charred compacts and re-pressing the resulting aggregate with the emulsified asphalt binder to find the preferred method for making charred peat briquettes.

Table 1 lists the compressive strengths in load kilograms and percent fines generated on five drops. It can be noted that the dry peat compacted with 6.5% asphalt yielded excellent strength, up to 430 load kilograms (950 lbs) crushing strength with good handling properties. Foundry coke briquettes, also showed good handling strength based on the percent fines generated on the drop test.

A typical drop test consists of dropping 20 Kg of + 10 mm material four times from a height of 2 m. The shatter index is the percentage of + 10 mm material surviving the test. The results of such a shatter test may be correlated with those of tumbling and abrasion tests.

In this particular test of evaluating the strength of peat char compacts, the % of fines were determined on five drops of a single briquettte from 2 m to the concrete floor and the % fines so generated should be considered only as a qualitative measure of the strength of these briquettes.

TABLE 1 EXPLORATORY PEAT BRIQUETTE EVALUATION

Description of Briquetted Material	Forming Pressure (kg/m^2)	Comprehensive Strength (kg)	% Fines Generated on Drop Test (6 ft. fall to Concrete floor)	Comments
Dry Peat - no Binder	7.03×10^6	Not determined	2.2%	Good strength
Dry Peat - 6.5% Asphalt	7.03×10^6	430 345 388 Avg.	0.1	Excellent strength
Dry Wetox Char - 6.5% Asphalt	7.03×10^6	111 99 105 Avg.	28.6	Broke into pieces
Foundry Coke - 6.5% Asphalt	7.03×10^6	Not determined	0.2	Excellent strength
Dry Peat Compact - Charred 450°C			9.4	Moderate strength
Peat Char Fines - Repressed, 6.5% Asphalt	7.03×10^6	Not determined	Not determined	Broke into pieces

TABLE 2 COMPOSITION OF PEAT AND PEAT CHARS

Proximate Analysis (Dry Basis)

	% Moisture	% Ash	% Volatile	% Fixed Carbon	% Sulphur	Total*
Ontario Peat	1.25	5.17	77.05	16.53	0.18	100.18
Loose Ontario Peat Charred at 500°C	0.01	10.81	51.22	37.97	0.15	100.16
Wetox Char - Quebec	2.79	13.76	68.65	14.80	0.01	100.01

Ultimate Analysis (Dry Basis)

	% C	%H	%N	%S	% Ash	% O (Difference)	Heating Value MJ/Kg
Ontario Peat	-	-	-	-	-	-	-
Wetox Char - Quebec	65.4	5.3	1.8	0.1	15.5	27.4	27.58
Ontario Peat Compacts Charred at 450°C	-	-	-	-	-	-	27.75
Ontario Peat Compacts Charred at 550°C	-	-	-	-	-	-	27.50

* Lab Report is attached.

More comprehensive tests would need to be done to obtain absolute data for comparison with briquettes made from other materials. To accomplish this a minimum of 100 Kg of material would be required.

The Wetox char compacted at $7.03 \cdot 10^6$ kg/m^2 (10,000 psi) with 6.5% asphalt exhibited low compressive strength combined with a large generation of fines 28.6% on dropping to the concrete floor.

The dry peat compacts charred at 450°C were rather hard and brittle and showed lateral cracks. Generation of 9.4% fines on dropping is considered unsatisfactory when compared to foundry coke properties. Briquettes produced from ground peat char and 6.5% asphalt at $7.03 \cdot 10^6$ kg/m^2 (10,000 psi) forming pressure did not stand up to the drop test.

Table 2 lists the proximate analyses of peat and chars as produced as well as an ultimate analysis on the Wetox char.

It can be noted that charring of the Ontario peat in loose form at 500°C increased the percentage of fixed carbon to 38% whereas the fixed carbon of Wetox char is about the same as that of dry Ontario peat. The volatiles in the charred Ontario peat are higher than expected, which is explained below.

Reactivity of Peat Char

A peat char briquette, charred at 550°C under nitrogen for one hour, was pressed with binder and tested for reactivity in comparison with a briquette made from foundry coke using the same binder. Both briquettes were heated in flowing carbon dioxide for exactly one hour at 1000°C and cooled carefully in nitrogen to avoid further oxidation.

Reactivity of carbon is based on the rate of reaction between the carbon in the carbonaceous material and CO_2 to form CO at 1000°C.

While the foundry coke briquette yielded a 8.8% weight loss, the peat char briquette lost 60.6% of its original weight. In the case of the foundry coke briquette, the weight loss is due to the loss of carbon reacted with CO_2.

The weight loss for the peat char briquette is due to loss of carbon as well as loss of volatiles. For this reason, the loss in weight figure does not reflect the true reactivity for this material.

For comparison, reference data of various carbonaceous materials yielded the following results:

Type Carbonaceous Material	% Weight Loss
Petroleum coke	9
Foundry coke	13
Char from High Volatile steam coal	47
Char coal	57
Antracite char	15-17

These results were obtained on -200 Mesh coals devolatized at 1050°C in N_2, then contacted with CO_2 for 1 hour at 1000°C and the loss in-weight is corrected for ash content. Thus, on the ash-free basis, the char from a HV steam coal lost 47% of its weight via the reaction $C + CO_2 \text{ ---> } 2\ CO$.

In comparison, the foundry coke lost only 13% by weight. This indicates that foundry coke is much less reactive with CO_2. In the foundry operation, complete combustion of fuel carbon to carbon dioxide is desired for maximum heat release, which in turn, is used to melt iron scrap. Reaction of CO_2 with fuel carbon is endothermic and reduces heat output.

In case there is excessive CO formation caused by small coke size, high reactivity or both, combustion of a great portion of this undesirable CO is quite feasible. This was demonstrated by the British Cast Iron Research Association by installing a second row of tuyeres. Thus, the CO produced from the primary combustion would burn when passing the second row of air blasts. There is room, of course, for a third row of tuyeres if required.

It could well be that high reactivity peat char could be used economically in such a system. This is particularly so if peat char briquettes can be marketed for less than conventional foundry coke.

6. CONCLUSIONS AND RECOMMENDATIONS

The intent of this program was to produce Peat Char with removal of the volatiles to take place at minimum temperatures for maximum cost savings. This approach is opposed to producing peat coke at higher temperatures, say 900-1100°C.

The results obtained indicates that temperatures higher than 450-550°C are required to remove volatiles more completely.

As mentioned in the Background section of this report coke breeze was successfully compacted with emulsified asphalt and the resulting briquettes had good green and dried strength. Attempts to briquette peat char fines by this method failed. It is felt that peat char that is more completely devolatilized will respond to this procedure and produce acceptable briquettes.

This is based on the assumption that char particles having a low volatile content are bonded with asphalt more firmly than char having a high volatile content. Thus, any future programs on this subject should address the following items:

- o Establish minimum temperature for removing at least 90-95% of the volatile content.
- o Demonstrate that loose char, sized -1/4 in., can be briquetted employing low cost binders using low-cost techniques.
- o Conduct reactivity tests to establish a true reactivity for the devolatilized peat char, vis-a-vis foundry coke on an ash free basis.
- o Estimate the quantity of peat char usage relative to foundry coke for making cast iron.

It is felt that alternate feed stock fuels such as peat char have a potential for making cast iron. This depends on the performance and price of peat char once initial feasibility has been established.

H.G. Brandstatter, P. Eng.,
Technical Manager
Pilot Plants and Process
Development
Mineral Resources Centres

A.J. Last,
Pyrometallurgy and
Energy Consultant

ASSAYERS (ONTARIO) LIMITED
33 CHAUNCEY AVENUE TORONTO, ONTARIO M8Z 2Z2 · TELEPHONE (416) 239-3527

Certificate of Analysis

Certificate No. ORF-57/ #2867 Date: February 29, 1984

Received 4 Samples of Peat

Submitted by Ontario Research Foundation Att'n: Mr. A.J. Last

P.O. 29271

	A	"Dried" B	C	D
Moisture	1.25 %	.67 %	<.01 %	2.79 %
Ash	5.17 %	9.12 %	10.81 %	13.76 %
Volatile Matter	77.05 %	73.23 %	51.22 %	68.65 %
Fixed Carbon	16.53 %	16.97 %	37.97 %	14.80 %
Sulphur	.18 %	.12 %	.15 %	.01 %

B - Original 91.20 % Moisture

A - Peat dried at 120°C for 12 hours

B - Peat as received

c - Sample A briquetted & charred

D - Dry peat from Wetox

ASSAYERS (ONTARIO) LIMITED

Per _____

J. van Engelen Mgr.

APPENDIX C

QUESTIONNAIRES

C1: Coke Users Survey Including Information Sheet

C2: Tar Users Survey Including Information Sheet

C3: Activated Carbon Users Survey

COKE USERS QUESTIONNAIRE:

1) Please classify your operation by checking the appropriate box.

Chemical Producer	Ferro-Alloy Producer	Mining & Smelting	Other
☐	☐	☐	☐

Describe: _____

2) Please briefly describe the products that incorporate coke or use coke in the manufacturing process.

Describe: _____

_____

_____

3) Are you familiar with current applications of **Peat Coke** ? Please circle the appropriate number.

No knowledge ——————————————— High Knowledge

1 2 3 4 5

4) Please identify your average yearly consumption of coke. If you do not use coke you have finished the questionnaire. Thank you for your assistance. Please mail the completed portion in the envelope provided.

Less than 2,000 tonnes	2,000 to 10,000 tonnes	10,000 to 20,000 tonnes	20,000 to 50,000 tonnes
☐	☐	☐	☐

50,000 to 100,000 tonnes	Greater than 100,000 tonnes
☐	☐

5) Do you use coal-based or petroleum-based cokes in your plant?

Coal-based ☐ petroleum-based ☐ mixture ☐

If a mixture, what percentage is petroleum based %

Comments: _____

_____

6) What is the coke being used for?

Carbon source ☐ reducing agent ☐ other ☐

Describe: _____

_____

7) What are your current specifications for coke? Please identify the appropriate ranges. Rank the importance by assigning 1 to the most important specification, 2 to the next important one, and so on.

Fixed Carbon %: _____

Ash %: _____

Sulphur %: _____

Volatile matter%: _____

Calorific Value: _____

Density: _____

Size: _____

Other, Please Specify: _____

_____

8) Is your coke sourced in Canada or is it imported?

Canada ☐ Imported ☐ Don't Know ☐

Comments: _____

_____

9) Does the high reactivity of Peat Coke affect your process?

Offers Processing Advantages ☐ Undesirable for Process ☐ No Effect ☐ Do Not Know ☐

Please Describe: _____

_____

10) Does the high electrical resistance of Peat Coke affect your process?

Offers Processing Advantages ☐ Undesirable for Process ☐ No Effect ☐ Do Not Know ☐

Please Describe: _____

_____

11) If Peat Coke were available would you be willing to test the product?

Yes ☐ No ☐ Do Not Know ☐

Comments: _____

_____

12) Please feel free to add any further comments.

Thank you for your assistance. Please mail the completed questionnaire in the envelope provided. If you would like a copy of the final report please attach your business card to the questionnaire.

COKE SPECIFICATIONS SHEETS:

Table 1. Chemical properties of coke produced out of pure high moor black peat.

Ash	3.5 % (dry basis)
Fixed carbon	91.06 % "
Hydrogen	1.51 % "
Nitrogen	1.39 % "
Sulphur (entire)	0.21 % "
Iron	0.14 % "
Calcium	0.38 % "
Magnesium	0.48 % "
Aluminium	0.20 % "
Silicon	0.95 % "
Chlorine	-
Sodium	0.09 % "
Potassium	0.06 % "
Copper	-
Phosphorus	0.03 % "

The reactivity of black peat coke to carbon dioxide at 1000 °C is between 14 and 20 times greater than that of first quality blast furnace coke.

Table 2. Physical properties of coke produced out of pure high moor black peat.

Grain size	mm	up to 200
Largest grain	mm	30 x 60 x 200
Apparent density	g/cm³	0.664
Real density	g/cm³	1.776
Porosity	%	75
Bulk density (coarse coke)	kg/m³	290
Bulk density (coke dust)	kg/m³	450
Caloric heat value H	kJ/kg	32 310
Effective heat value $^{o}H_{u}$	kJ/kg	32 075
Specific electrical resistance	Ohm mm²/mm	-
Ignition point	°C	230
Surface area measurement	m²/g	up to 220*
Ash fusing temperatures:		
Sintering point	°C	1040
Softening point	°C	1230
Fusing point	°C	1250

*Here should be added: With activated carbons, produced out of pure black peat coke by further calzination or activation, respectively, surface areas of some 100 m²/g up to 1500 m²/g and more can easily be reached.

Source: H. Grumpelt, "Development of Peat Coke production', 1982

The main elements in coke manufactured from Finnish peat are the following:

fixed carbon	80 - 93 %
volatiles	12 - 2 %
ash	3 - 8 %

An average analysis of peat ash:

potassium oxide	K_2O	0.5 - 5 %
calcium oxide	CaO	5 - 15 %
ferro oxide	Fe_2O_3	5 - 15 %
aluminium oxide	Al_2O_3	15 - 35 %
silicon dioxide	SiO_2	35 - 65 %
sulphur	S	0.5 - 3 %
phosphorus	P	1.3 - 1.6 %

Generally, peat coke can be used for all purposes where carbonization is needed and impurities cause difficulties. Peat coke has a high reactivity, low content of impurities, especially sulphur and phosphorus, and it burns with a smooth, strong and smokeless flame.

Source:
T. Laukkanen, J. Hanni,
'Peat Technology developed
by Outokumpu Oy', 1978

The proportions of the main elements of peat and peat coke are as follows:

	Peat	Coke
carbon %	57	90 - 84
oxygen %	35	6 - 10
hydrogen %	5.7	2 - 4
nitrogen %	1.5	1.5
Other values:		
volatiles %	62 - 70	2 - 10
effective calorific value kcal/kg	4800 - 5200	7400
MJ/kg	20 - 22	31

The proporations of contaminants are as follows (the values reflect tests made by the State Technical Research Centre in their pilot plant for two peat types only and are not averages for peat as a whole):

	Peat	Coke
ash %	0.7 3.6	2.5 10.1
sulphur %	0.10 0.15	0.13 0.22
phosphorus %	0.052 0.048	0.061 0.094
iron %	0.41 0.31	0.18 0.76

Source: P. Komonen, ' Manufacture of Peat Coke', 1974

TAR USERS QUESTIONNAIRE:

1) Please specify the type of tars used in your operation?

Coal Based	Petroleum Based	Other
☐	☐	☐

If a fraction or specific tar component please describe:

_____

_____

2) Are you familiar with the use of peat tars?
Please circle the appropriate number.

No Knowledge _____ High Knowledge

1 2 3 4 5

3) On average, what yearly quantity of tar is used in your plant(s)?

Less than 2,000 tonnes	2,000 to 10,000 tonnes	10,000 to 20,000 tonnes	20,000 to 50,000 tonnes
☐	☐	☐	☐

Greater than 50,000 tonnes

☐

4) Please list the tar based products that you manufacture.

_____

_____

_____

Please refer to the peat tar description sheet.

Please specify your feedstock requirements. Rank the importance by assigning 1 to the most important requirement, 2 to the next important, and so on.

Aliphatic Fractions: _____

Aromatic Fractions: _____

Sulphur Range: _____

Ash Ranges: _____

Vapour Pressure: _____

Flash Point: _____

Other requirements,

Please describe: _____

_____

_____

6) If peat tars were available would you be willing to test their use in your process?

Yes	No	Need Additional Information
☐	☐	☐

Comments: _____

_____

_____

7) Please feel free to add any further comments.

Thank you for completing the questionnaire. Please mail the completed questionnaire in the envelope provided. If you would like a copy of the final report please attach your business card to the questionnaire.

PEAT TAR DESCRIPTION

PEAT TARS ARE MULTI-MATERIAL MIXTURES WHICH, IN CONTRAST TO COAL TARS, ARE ALIPHATIC IN NATURE. THEY HAVE A RELATIVELY HIGH PARAFIN CONTENT AND OLEFINIC COMPONENTS. THEY ALSO TEND TO HAVE VERY LOW SULPHUR AND ASH CONTENTS (i.e. SULPHUR APPROXIMATELY 0.16% BY WEIGHT DEPENDING ON THE PEAT SOURCE).

THEY HAVE LOW SOFTENING (AROUND 45°C) AND FLAME POINTS (AROUND 105°C). THE HEATING VALUE IS APPROXIMATELY 9000 KCAL/KG.

SOURCE:- 'DEVELOPMENT AND PRESENT STATE OF PEAT COKE PRODUCTION'
H. GRUMPELT, 1979

ACTIVATED CARBON USERS QUESTIONNAIRE:

1) Please indicate type of industry by checking the appropriate box.

Beverage Manufacturers

Distillery ☐ Brewery ☐ Winery ☐ Soft Drink ☐ Sugar Processors ☐ Textiles ☐

Printing ☐ Chemical Industries ☐ Air Conditioning ☐ Water & Effluent Treatment ☐

Other ☐ Describe: _____

_____

2) What type of activated carbon are you using in your plant or in the equipment you manufacture?

Powdered ☐ Granular ☐ Extruded ☐ Catalytic ☐

Other ☐ Specify: _____

_____

If you do not use activated carbons you have finished the questionnaire.
Please mail the questionnaire in the self-addressed envelope.
Thank you for your assistance.

3) Is your activated carbon regenerated?

Yes ☐ No ☐

If, Yes, how is this done?

Re-activated in Plant ☐ Sent back to Supplier ☐

Comments: _____

_____

4) Is the activated carbon used as a liquid-phase adsorbant or as a gas-phase adsorbant?

Liquid Phase ☐ Gas Phase ☐ Don't Know ☐

5) Do you know the base material used to fabricate your activated carbon?

If a mixture, please check the appropriate boxes.

Coal ☐ Peat ☐ Charcoal ☐ Coconut Shell ☐ Sawdust ☐ Petroleum Coke ☐

Other ☐ Describe: _____

_____

_____

Don't Know ☐

6) What yearly quantity do you normally use?

Less than 1,000 kilos	1,000 to 5,000 kilos	5,000 to 20,000 kilos	20,000 to 50,000 kilos
☐	☐	☐	☐

50,000 to 100,000 kilos	Greater than 100,000 kilos
☐	☐

7) What contaminant is adsorbed by the activated carbon?

Describe: _____

_____

_____

8) Did your activated carbon supplier design the current installation?

Yes	No	Don't Know
☐	☐	☐

9) Does your process impose any special restriction on the activated carbon?

Describe: _____

_____

_____

10) Please feel free to add any further comments.

_____

_____

Thank you for your assistance. Please mail the completed questionnaire in the envelope supplied. If you would like a copy of the final report please attach your business card to the questionnaire.

APPENDIX D

OPERATING AND CAPITAL COSTS OF PEAT COKING PLANTS

D1: Outokumpu Oy Coking Plant

D2: Outokumpu Oy Coking Plant and Power Station

D3: Outokumpu Oy Coking Plant, Power Station and Briquetting Plant

D4: Wielandt Process Coking Plant

D5: Lurgi-Salem Coking Plant and Power Station

D6: Explanatory Notes

D1: Outokumpu Oy Coking Plant

Notes											
(1)	Qty. of sod peat(tonnes)	300000									
(2)	Cost factor	0.097									
(3)	Scaling factor	1.495									
	Coke production	30000									
	Fines production %	5									
	Capital subsidy %	0									
	Discount factor %	15									
	PRODUCTION										
(4)	sod production year		-3	-2	-1	1	2	3	4	5	
(5)	coke production year		-5	-4	-3	-2	-1	1	2	3	
	sod prod volume %					33	75	63	50	100	
	coke prod volume %							60	75	100	
	CAPITAL COSTS										
	Mining Costs		6640039.16	6829569.67	6655434.70	01253322.03	6579951.41	6579951.41	6394606.11		
	Manuf. Costs	59660000.00				05756000.00	03864000.00				
	Sub Total		6640039.16	6829569.67	6655434.70	07049322.03	04443951.41	6579951.41	6394606.11	00.00	
	OPERATING COSTS										
	mining maintenance	01139436.02				6432985.43	6854577.81	6948731.00	01025498.41	01139436.02	
	mining labour	01253379.62				6476284.25	6940034.71	01040308.00	01138041.66	01253379.62	
(6)	manuf. maintenance	6579600.00						6347760.00	6434700.00	6579600.00	
	manuf. labour man	4						2	3	4	
	manuf. labour costs							0280000.00	0420000.00	0560000.00	
	quality control	0140000.00				00.00	00.00	0140000.00	0140000.00	0140000.00	
	fixed overhead	0340000.00				01700000.00	01700000.00	0340000.00	0340000.00	0340000.00	
	Total Operating					01979269.94	01964611.72	03093796.00	03480234.07	04012415.63	
	Capital cost		6640039.16	6829569.67	6655434.70	08126592.77	06408563.14	6579951.41	6394606.11	00.00	
(7)	Working Capital				0134900.74	0110667.72	0141140.16	049304.64	065522.76		
(8)	Construction Int.		0560418.45	0523422.97	0274118.06	01895883.54	0463035.19				
	Capitalized		01200457.61	01352992.25	01064461.58	010138134.03	07313566.48	6579951.41	6394606.11	00.00	
	TOTAL PRE-PROD. CAPITAL						020766631.95				
	COSTS OF PRODUCTION										
(13)	capital cost factor							0.1398	0.1613	0.1632	
	capital cost recovery							03317707.66	03611274.90	04078660.21	
	operating costs							03093796.00	03480234.07	04012415.63	
	Total costs							06411504.63	06699508.97	07400804.84	
	PRODUCTION										
	Post coke production							18000	22500	30000	
	Less fines							900	1125	1500	
	Coke produced(tonnes)							17100	21375	28500	
	COST/TONNE							0374.94	0322.70	0262.74	

D2: Outokumpu Oy Coking Plant and Power Station

Notes										
[1]	See appendix B7									
[2]	Qty. of sod peat(tonnes)	200000								
[3]	Cost factor	0.897								
	Scaling factor	1.495								
	Coke production	30000								
	Fines production %	5								
	Discount factor %	15								
	PRODUCTION									
[4]	sod production year		-3	-2	-1	1	2	3	4	5
[5]	coke production year		-5	-4	-3	-2	-1	1	2	3
	sod prod volume %					30	75	83	90	100
	coke prod volume %							60	75	100
	CAPITAL COSTS									
	Mining Costs									
	Manuf. Costs	0200000000.00	0640039.16	0829569.67	0655434.78	013253322.03	05799951.41	0579951.41	0394686.11	
						013000000.00	08000000.00			
	Sub Total		0640039.16	0829569.67	0655434.78	013253322.03	05799951.41	0579951.41	0394686.11	00.00
	OPERATING COSTS									
	mining maintenance	011139436.62								
	mining labour	012533379.62				0432905.69	0854577.01	0945731.09	010825492.41	011139436.62
[6]	manuf. maintenance	01200000.00				0476204.23	0948034.71	01040305.00	011200041.45	012533379.62
	manuf. labour man	6						07200000.00	08000000.00	01200000.00
	manuf. labour costs							3	4	6
	quality control	0140000.00						0420000.00	0560000.00	0840000.00
	fixed overhead	0340000.00						0140000.00	0140000.00	0140000.00
	Total Operating					0170000.00	0170000.00	0340000.00	0340000.00	0340000.00
						01079269.94	01964611.72	03600036.90	04033534.07	04912815.63
	Capital cost									
[7]	Working Capital		0640039.16	0829569.67	0655434.78	0142322982.77	0103443563.14	0579951.41	0394686.11	
[8]	Construction Inc.		0560418.45	0523422.87	0134900.74	0110667.72	0205170.16	0GB937.14	0102416.28	
					0274118.06	03342099.67	0763221.06			
	Capitalized		01200457.61	01352992.25	01064461.58	0177966166.16	0115512962.35	0648880.55	0497616.31	00.00
	TOTAL PRE-PROD. CAPITAL						0329179033.95			
	REVENUE FROM COKE									
[9]	Electric power(50Hz)	50000000								
[10]	Thermal power(150Hz)	150000000	02.50					0750000.00	0937500.00	01250000.00
			02.00					01000000.00	02250000.00	03000000.00
	Total Revenue							01750000.00	03187500.00	04250000.00
	COSTS OF PRODUCTION									
[11]	capital cost factor							0.1590	0.1654	0.1679
	capital cost recovery							05250872.75	03364085.47	04440320.21
	operating costs							03600036.90	04033534.07	04912815.63
	Sub Total							08864910.72	07397619.54	09353135.85
	Less revenue							01750000.00	03187500.00	04250000.00
	Total costs							07114910.72	04210119.54	05103135.85
	PRODUCTION									
	Peat coke production							10600	22500	30000
	Less fines							500	1125	1500
	Coke produced(tonnes)							17100	21375	28500
	COST/TONNE							0369.29	0293.37	0214.43

D3: Outokumpu Oy Coking Plant Power Station and Briquetting Plant

[1]	Qty. of sod peat(tonnes)	200000									
[2]	Cost factor	0.897									
[3]	Scaling factor	1.495									
	Coke production	30000									
	Fines production %	5									
	Discount factor %	15									
	PRODUCTION										
[4]	sod production year		-3	-2	-1	1	2	3	4	5	
[5]	coke production year		-5	-4	-3	-2	-1	1	2	3	
	sod prod volume %					30	75	63	90	100	
	coke prod volume %							60	75	100	
	CAPITAL COSTS										
	Mining Costs		0640039.16	0629569.67	0655434.78	012253322.03	0579951.41	0579951.41	0394686.11		
	Manuf. Costs	020004000.00				012000000.00	00000000.00				
	Briquetting costs	04600000.00					04600000.00				
	Sub Total		0640039.16	0629569.67	0655434.78	013253322.03	013179951.41	0579951.41	0394686.11		
	OPERATING COSTS										
	mining maintenance	01139436.02				0432949.69	0854977.01	0845731.09	010825492.41	011139436.02	
	mining labour	01253379.62				0476284.25	0940834.71	01040385.68	011120841.46	01253379.62	
[6]	manuf. maintenance	01200000.00						0720000.00	0900000.00	01200000.00	
	manuf. labour man	10						6	7	10	
	manuf. labour costs							0840000.00	0980000.00	01400000.00	
	quality control	0140000.00						0140000.00	0140000.00	0140000.00	
	fixed overhead	0340000.00				0170000.00	0170000.00	0340000.00	0340000.00	0340000.00	
	Total Operating					01079269.94	01964811.72	04026036.90	04815534.07	05472815.63	
	Capital cost		0640039.16	0629569.67	0655434.78	014332592.77	015144963.14	0579951.41	0394686.11	00.00	
[7]	Working Capital										
[8]	Construction Int.		0560418.49	0523422.57	0274110.66	03343099.67	01896171.58	668937.14	0119918.28	00.00	
	Capitalized		01200457.61	01152992.25	01064461.50	017706160.16	016490412.79	0648888.55	0514516.31	00.00	
	TOTAL PRE-PROD. CAPITAL						037902404.30				
	REVENUE FROM COKE										
[9]	Electric power(50MW)	50000000						0750000.00	0937500.00	01250000.00	
[10]	Thermal power(150MW)	150000000						01800000.00	02250000.00	03000000.00	
[11]	Briquettes(40 k.tonnes)	40000						01367730.00	01709662.50	02279550.00	
	price0/million BTU	03.25									
	Total Revenue							03917730.00	04897162.50	06529550.00	
	COSTS OF PRODUCTION										
[12]	capital cost factor							0.1380	0.1613	0.1632	
	capital cost recovery							00859356.64	01135048.58	01190810.51	
	operating costs							04026036.90	04815534.07	05472815.63	
	Sub Total							04885393.61	05950582.57	06663626.14	
	Less revenue							03917730.00	04897162.50	06529550.00	
	Total costs							00967663.61	01053420.07	00134076.14	
	PRODUCTION										
	Post coke production							18000	22500	30000	
	Less Fines							900	1125	1500	
	Coke produced(tonnes)							17100	21375	28500	
	COST/TONNE							0360.49	0268.14	0180.43	

Notes:- See Appendix B7

D4: Wielandt Process

[1]	Qty. of seed peat(tonnes)	60000								
[2]	Cost factor	1.100								
[3]	Scaling factor	0.592								
	Coke production	15000								
	Fines production %	0								
	Discount factor %	15								
	PRODUCTION									
[4]	seed production year		-2	-2	-1	1	2	3	4	5
[5]	coke production year		-0	-4	-3	-2	-1	1	2	3
	seed prod volume %					30	70	80	70	100
	coke prod volume %							60	70	100
	CAPITAL COSTS									
	Mining Costs									
	Manuf. Costs	0115000000.00	0253701.26	0320820.11	0259003.03	09396797.06	04229003.44	0229003.44	0156419.53	00.00
						06900000.00	44000000.00			
	Sub Total		0253701.26	0320820.11	0259003.03	07396797.06	04829003.44	0229003.44	0156419.53	00.00
	OPERATING COSTS									
	mining maintenance	0596761.54								
	mining labour	0821484.89				0226769.30	0447571.16	0490312.00	0337605.30	0596761.54
[6]	manuf. maintenance	0345000.00				0312164.26	0616113.67	0681032.46	0738336.00	0821484.89
	manuf. labour man	4						0287000.00	0286750.00	0345000.00
	manuf. labour costs							2	3	4
	quality control	0140000.00						0350400.00	0325600.00	0700000.00
	Fixed overhead	0340000.00						0140000.00	0140000.00	0140000.00
	Total Operating					0170000.00	0170000.00	0340000.00	0340000.00	0340000.00
						0708933.64	01233684.82	02214544.54	02540771.79	03940446.43
	Capital cost		0253701.26	0320820.11	0259003.03	08165730.71	06062568.26	0229003.44	0156419.53	00.00
[7]	Working Capital				000616.71	645593.90	0122607.46			00.00
[8]	Construction Inc.		0222140.88	0207476.31	0186436.80	01890561.25	0438084.28			
	Capitalized		0475842.14	0528304.42	0457076.54	010661885.85	06625860.00	0229003.44	0156419.53	00.00
	TOTAL PRE-PROD. CAPITAL						0101561160.96			
	COSTS OF PRODUCTION									
[13]	capital cost factor									
	capital cost recovery							0.1598	0.1613	0.1632
	operating costs							02900656.25	02937744.00	02963369.67
								02214544.54	02540771.79	02940446.43
	Total							05115200.79	05478516.50	05907316.11
[12]	Less Tar Revenue							0106000.00	0133312.50	0177750.00
	Total Costs							05009550.79	05345204.00	05729566.11
	PRODUCTION									
	Peat coke production							9000	11250	15000
	Less fines							0	0	0
	Coke produced(tonnes)							9000	11250	15000
	COST/TONNE							0560.36	0486.90	0393.82

D5: Lurgi Salem Coking Plant and Power Station

Notes											
(1)	Qty. of coal post(tonnes)	200000									
(2)	Cost Factor	0.057									
(3)	Scaling Factor	1.499									
	Coke production	30000									
	Fines production %	10									
	Discount Factor %	15									
	PRODUCTION										
(4)	coal production year		-3	-2	-1	1	2	3	4	5	
(5)	coke production year		-6	-4	-5	-2	-1	1	2	3	
	coal prod volume %					10	75	83	90	100	
	coke prod volume %							60	75	100	
	CAPITAL COSTS										
	Mining Costs		$648039.16	$829569.67	$655434.78	$1253322.03	$579951.41	$579951.41	$394686.11		
	Manuf. Costs	$26250000.00				$15750000.00	$10500000.00				
	Sub Total		$648039.16	$829569.67	$655434.78	$17003322.03	$11079951.41	$579951.41	$394686.11	$0.00	
	OPERATING COSTS										
	mining maintenance	$11339436.62									
	mining labour	$1253379.62				$432905.69	$804577.01	$943731.69	$1025498.41	$11339436.62	
(6)	manuf. maintenance	$1312500.00				$476284.25	$840834.71	$1040385.00	$1128041.66	$1253379.62	
	manuf. labour man	6						$787500.00	$984375.00	$1312500.00	
	manuf. labour costs							5	6	6	
	quality control	$140000.00						$420000.00	$560000.00	$840000.00	
	Fixed overhead	$340000.00				$0.00	$0.00	$140000.00	$140000.00	$140000.00	
						$170000.00	$170000.00	$340000.00	$340000.00	$340000.00	
	Total Operating					$1079269.94	$1964411.72	$3673036.90	$4177909.07	$15825315.63	
	Capital cost		$648039.16	$829569.67	$655434.78	$18082592.77	$13044563.14	$579951.41	$394686.11		
(7)	Working Capital				$134900.74	$118667.72	$213615.66	$63046.51	$103929.82	$0.00	
(8)	Construction Int.		$560410.48	$523422.87	$274110.66	$421750.70	$944172.39				
	Capitalized		$1208457.61	$1352992.28	$1064461.80	$22410001.19	$14202251.18	$642997.92	$508931.93	$0.00	
	TOTAL PRE-PROD. CAPITAL						$40231063.01				
	REVENUE FROM COKE										
(9)	Electric power(50Mw)	50000000									
(10)	Thermal power(150Mw)	150000000						$750000.00	$937500.00	$1250000.00	
								$1500000.00	$2250000.00	$3000000.00	
	Total Revenue							$2250000.00	$3187500.00	$4250000.00	
	COSTS OF PRODUCTION										
(11)	capital cost factor							0.1390	0.1613	0.1632	
	capital cost recovery							$6427373.91	$6531112.00	$6613752.80	
	operating costs							$3672536.90	$4177909.07	$15825315.63	
	Sub Total							$10100910.80	$10709021.92	$11639100.43	
	Less Revenue							$2250000.00	$3187500.00	$4250000.00	
	Total costs							$7850910.80	$7521521.92	$7389100.43	
	PRODUCTION										
	Post coke production							18040	22500	30000	
	Less fines							1804	2250	3000	
	Coke produced(tonnes)							16236	20250	27000	
	COST/TONNE							$466.11	$371.43	$273.63	

D6: EXPLANATORY NOTES

See Appendices D1 through D5 for references

1) Quantity of sod peat at 40% moisture required to sustain plant capacity.

2) Cost factor = cost increase/decrease per tonne of peat coke compared to 120,000 tonnes base estimate.

3) Scaling factor = sod peat tonnes/120,000 tonnes *cost factor. This factor used to scale mining costs.

4) Sod production year: year 1 is end of first year of peat sod production.

5) Coke production year: year 1 is end of first year of peat coke production.

6) Capital Cost Estimates inculde design and construction costs.

($'000)

	OUTOKUMPU OY	LURI SALEM
Drying Drum	1,628	1,628
Coking & Cooling Drums	5,116	11,366
Waste Heat Boiler & Power Plant	10,233	10,233
Pipelines, Power Lines & Instrument	3,023	3,023
Total	20,000	26,250

	WIELANDT
Production Plant Includes:	
Retorts, Tar Recovery	11,500
Purfication Plant	
Total	11,500

7) Manufacturing maintenance estimates:

Outokumpu Oy = 6% of manufacturing capital cost
Lurgi-Salem = 5% of manufacturing capital cost
Wielandt = 3% of manufacturing capital cost

8) Working capital = next year operating cost * 1.5/12.

9) Construction interest = capital cost * [(1 + discount rate) raised to the power (year - 0.5) - 1].
year = time to start up of coke plant

10) Electric power sold for 2.5¢ per kwh.

11) Thermal power sold for 2.0¢ per kwh.

12) Briquettes: price for briquettes is based on estimated prices per million BTU's.
Thermal value of 35% moisture sod peat fines = 7,000 BTU/lb.
Thermal value coke fines = 11,800 BTU/lb (see ORF report, Appendix A).
Assume briquettes 80% sod peat + 20% coke fines = 8,000 BTU/lb

$$\text{BTU/tonne} = 8{,}000 \frac{\text{BTU}}{\text{lb}} \times \frac{1 \text{ lb}}{0.454 \text{ kg}} \times 1{,}000 \text{ kg/tonne}$$

$$= 17.6 \text{ million BTU/tonne}$$

at $\$3.25/10^6$ BTU, Briquettes = \$57/tonne.

13) Peat Tar: Price for peat tar is based on price of Bunker C.
assumed + 5.56/10^6 BTU
Bunker C = 43,000 KJ/kg
Peat Tar = 9,000 KJ/kg
Price of Peat Tar =

$$9{,}000 \times \frac{1}{1{,}055} \times 1{,}000 \times \frac{5.56}{1{,}000{,}000} = 47.0 \text{ \$/tonne.}$$

Peat tar production: assumed 1/4 of peat coke production.

14) Capital cost factor = [discount rate/(1-(1 + rate %)m]
where m = years of coke production left in 20 year plant life.
This factor represents a simple annuity for m years at a specified discount rate.

APPENDIX E

LIST OF REFERENCES

LIST OF REFERENCES

Part 2: Production and Uses of Coke

1. P. Fasullo, J. Matson, T. Tarillion, 'Coke - U.S. Capacity Heading Up, Quality Down', Oil and Gas Journal, October 25, 1982.

2. N. Berkowitz, 'An Introduction to Coal Technology', Academic Press, 1979.

3. Quarterly Coal Report, DOE/EIA - 0121 (83, 1Q), January - March, 1983.

4. 'Will Sun Set on Steelmaking?', Toronto Star, March 3, 1984.

5. 'American Trustbusters Spoil Steelmakers' Fun', The Economist, February 18, 1984.

6. The Canadian Minerals Yearbook, 'Iron and Steel', 1978.

7. 'Stelco to Lobby Against Curbs Planned in U.S.', Globe and Mail, May 1, 1984.

8. 'Korea Faces Attack Over Export Steel Success', Globe and Mail, May 1, 1984.

9. 'Pittsburgh's Pirates', The Economist, February 25, 1984.

10. The Canadian Minerals Yearbook, 'Iron and Steel', 1980.

11. Canadian Mining Journal, February 1984, p. 76.

12. 'Making, Shaping and Treatment of Steel', United States Steel, 12th Edition.

13. Metal Bulletin, June 5, 1981, p. 21.

14. American Metal Market, March 26, 1980.

15. U.N. Yearbook of World Energy Statistics, 1980.

16. U.N. Monthly Bulletin of Statistics, December 1983.

17. H. Lowry, editor 'Chemistry of Coal Utilization', 1963.

18. Quarterly Coal Report, DOE/EIA - 0121 (82/4Q), October - December, 1982.

19. OECD, 'The Iron and Steel Industry in 1981', published in 1983.

Part 3: Activated Carbon

1. U.N. Yearbook of Industrial Statistics, 1981.

2. M. Holden, 'Manufacture and Uses of Activated Carbon', Effluent Water Treatment Journal, January 1982.

3. Brochure E64/840002, 'Black Makes White', Norit.

4. Encyclopedia of Chemical Technology, 'Activated Carbons', 1976.

5. G. L. Singer, '...Nor Any Drop to Drink.': Public Policies Toward Chemical Contamination of Drinking Water, P.U./CEES Report No. 140, June 1982, Princeton University Press.

6. File 84, Predicast International Time Series - 1983/ANC as reported in 'Japan Chemical'.

7. R. Martin, 'Activated Carbon Product Selection for Water and Wastewater Treatment', American Chemical Society, 1980.

Part 4: Carbon Black

1. Information Chimie no. 203 - juin - juillet, 1980.

2. OECD, 'The Chemical Industry 1980', published in 1983.

3. Encyclopedia of Chemical Technology, 'Carbon Black', 1977.

Part 5: Waxes

1. H. Bennet, 'Industrial Waxes,' Chemical Publishing Co., 1963.

2. Encyclopedia of Chemical Technology, 'Waxes', 1977.

3. L. Fagernas, R. Ekman, and R. Thun, 'A Study of the Extracts From Finnish Peat', 1984.

4. T. Peltola, J. Brandt, R. Thun; 'Combined Dewatering and Extraction of Peat', 1983.

Part 6: Tars

1. United Nations Yearbook of Industrial Statistics, 1981.

2. 'Making, Shaping and Treatment of Steel', United States Steel, 12th Edition.

3. N. Berkowitz, 'An Introduction to Coal Technology', Academic Press, 1979.

4. H. Lowry, 'Chemistry of Coal Utilization', Supplementary Volume, 1963.

5. H. Grumpelt, 'Development and Present State of Peat Coke Production'. In: Recent Technologies International Symposium of Deutsche Gesellschaft fur Moor - und Tjon/kunde e.v. (DGMT) and Section 11 of the International Peat Society (IPS), Bad Zwischenahn, BRD November 5-8, 1979. Shuttgart 1983.

Part 7: Peat Coke Preparation and Characteristics

1. Moilanen, A. & Ranta, J., 'Egenskaper hos industriell torv och dess testningsmetoder'. Delrapport 1. Frastorven forbranningstekniska egenskaper. Statens tekniska forskningscentral, Bransle-och smorjmedelslaboratoriet. Esbo, januari 1983.

2. Sokolov, S. G., 'Disperssin vaikutus turpeen rankenteesen ja fysi-kaalis-mekaanisiin ominaisuuksiin, kun on saatava korkeatasoista palaturvetta alhaisen vesipitoisuuden esiintymista'. Trudy Moskovskogo Torfjano Instituta; Vypusk III 1958. S. 140 - 166. (Translation from Russian into Finnish).

3. Ekman, E., 'Turve metallurgisen koksin ja aktiivihiilen raaka-ai-neena'. Kemia-Kemi 2(1975)2, s. 71-74.

4. Pirkonen, P. & Kukaanniemi, E., 'Palaturpeen lujuustutkimus. Oulun yliopisto, Prosessitekniikan osasto'. Raportti 24. Oulu 1979.

5. Grumpelt, H., 'Development and present state of peat coke production'. In: Recent Technologies International Symposium of Deutsche Gesellschaft fur Moor - und Tjon/kunde e.v. (DGMT) and Section 11 of the International Peat Society (IPS), Bad Zwischenahn, BRD November 5-8, 1979. Shuttgart 1983.

6. Vapo Oy. Information leaflet. Jyvaskyla 1982.

7. Vor 75 Jahren fing es an. Bentheim, C. Dilmann AG, 1978.

8. Ekman, E., 'Turvekoksi ja sen kaytto metalliteollisuudessa'. Konepajamies 1976:11, s. 33 - 37.

Part 7: Cont'd

9. Belkevich, P. & Gaiduk, K. A., 'Thermolysis of peat and its components'. Helsinki 1972. Proc. of the 4th Int. Peat Congr., Vol. 4., s. 143 - 164.

10. Kortschunov, V. S., 'Increasing of solid product yield in case of milled peat pyrolysis'. Helsinki 1973. Proc. of the 4th Int. Peat Congress, Vol. 4, s. 165 - 175.

11. Falbe, J., 'Chemierohstoff aus Kohle'. Schwelung und Verkokung. Stuttgart, Georg Thieme Verlag, 1977. S. 8 - 56.

12. N. Berkowitz, 'An Introduction to Coal Technology', Academic Press, 1979.

13. H. Lowry, editor 'Chemistry of Coal Utilization', 1963.

14. 'Making, Shaping and Treatment of Steel', United States Steel, 12th Edition.

15. 'Evaluation of the Potential of Peat in Ontario', Monenco Ontario Limited, 1981.

Part 8: Production Processes for Manufacturing Peat Coke

1. Jarvinen, T., Turvekoksitehdas. Lecture. Kemian Paivat, Helsinki 1981.

2. Grumpelt, H., 'Development and present state of peat coke production'. In: Recent Technologies in the Use of Peat, Reports of the International Symposium of Deutsche Gesellschaft fur Moor- und Tjorfkunde e.V . (DGMT) and Section II of the International Peat Society (IPS), Bad Zwischenahn, BRD. November 5 - 8, 1979. Stuttgart 1983.

3. Brandt, J. & Sipila, K., Travel report 1984.

4. Vor 75 Jahren fing es an. Bentheim, C. Deilmann AG, 1978.

5. Indu-Carbon GmbH. Information leaflet.

6. Rammler, R., 'Herdofen fur die Verkokung von Kohle, Einsatzmoglichkeiten und Ergebnisse'. Erdol and Kohle - Erdgas - Petrochemie vereinigt mit Brennstoff-Chemie, 32(1978)4, s. 181 - 186.

7. Rudolph, P., Schmalfeld, P. & Sauter, D., 'Gasification and carbonization of peat'. In: Recent Technologies in the Use of Peat, Reports of the International Symposium of Deutsche Gesellschaft fur Moor- und JTorfkunde e.V. (DGMT) and Section II of the International Peat Society (IPS), Bas Swischenahn, BRD. November 5 - 8, 1979. Stuttgart 1983. S. 149 - 167.

8. Coke production in the Salem Hearth Calciner. Lurgi express - Information 12/1982. 01456/12.82.

Part 9: Peat Coke Production Costs

1. Quarterly Coal Report, DOE/EIA-0121 (83, 3Q), July - September, 1983.

2. P. Fasullo, T. Tarillion, J. Matson, 'Price of Dwindling Supply of Better-Quality Coke', Oil and Gas Journal, November 8, 1982.

3. 'Silicon's Outstanding Potential', Metal Bulletin, May 13, 1983.

4. Statistics Canada, Catalogue 54-209.

5. Statistics Canada, Catalogue 31-211.

6. Statistics Canada, Catalogue 41-226.

7. Statistics Canada, Catalogue 65-207.

Part 10: Current Producers and Consumers of Carbon Products in Canada

1. Canadian Minerals Yearbook, 'Coal and Coke', 1980.

2. Canadian Mining Journal, 'Iron Ore', February 1984, p. 70.

3. Encyclopedia of Chemical Technology, 'Carbon Black', 1977.

4. Corpus Information Services, Carbon Black Product profile, November 15, 1983.

5. Statistics Canada: Catalogue 41-001, December 1982.

6. Statistics Canada: Catalogue 57-003.

7. Statistics Canada: Catalogue 26-224.

8. Statistics Canada: Catalogue 41-226.

9. Statistics Canada: Catalogue 65-207.

10. Statistics Canada: Catalogue 32-222.

11. Statistics Canada: Catalogue 31-211.

12. Statistics Canada: Catalogue 46-216.

13. Statistics Canada: Catalogue 45-004.

14. Statistics Canada: Catalogue 36-205.

Part 12: The United States as a Potential Market for Peat Coke and Activated Carbon

1. 'American Trustbusters Spoil Steelmakers' Fun, The Economist, February 18, 1984.

2. 'Pittsburgh's Pirates', The Economist, February 25, 1984.

3. Quarterly Coal Report, DOE/E1A-0121, (82, rQ), October - December, 1982.

4. Quarterly coal Report, DOE/E1A-0121, (83, 3Q), July - September, 1983.

5. United Nations, Monthly Bulletin of Statistics. December, 1983, Volume XXXVII.

6. Quarterly Coal Report, DOE/E1A-0121, (83, 1Q), January - March, 1983.

7. P. Fasullo, T. Tarillion, J. Matson, 'Price of Dwindling Supply of Better-Quality Coke', Oil and Gas Journal, November 8, 1982.

8. R. P. Greene, J. M. Gallagher; Editors, 'Future coal Prospects, Country and Regional Analysis'.

9. O.E.C.D., EUR: COKE OVENS Consumption of Metallurgical Coal. World Energy Outlook, 1982. P.298.

10. G. L. Singer, '...Nor Any Drop to Drink.': Public Policies Toward Chemical Contamination of Drinking Water, P.U./CEES report No. 140, June 1982, Princeton University Press.

Part 13: Other Geographical Areas as Potential Markets for Peat Coke

1. 'Electric Steelmaking - Key to Future', Metal Bulletin, June 5, 1981.

2. 'Demand for D.R. Iron Seen Hitting 92 m.m.t. in Decade', American Metal Market, March 26, 1980.

3. 'Pittsburgh's Pirates', The Economist, February 25, 1984.

4. 'Supply/Demand Outlook for Premium Scrap in International Trade - The Role of DRI': Skillings Mining Review, January 16, 1982.

5. Eurostat, Coal Monthly Bulletin, 11-1983.

6. Metal Bulletin, October 14, 1980, p.40.

7. The Japan Economic Journal, July 19, 1983.

8. 'American Trustbusters spoil steelmakers fun', The Economist, February 18, 1984.

9. Statistics Canada, Catalogue 26-206, Coal Mines.

10. R. P. Greene, J. M. Gallagher, Editors, 'Future Coal Prospects, Country and Regional Analysis', 1980.

11. 'Skillings Mining Review', January 16, 1982.

12. U.N. Yearbook of World Energy Statistics, 1980.